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U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY—BULLETIN NO. 12.
B. T. GALLOWAY, Chief of Bureau.

STOCK RANGES OF NORTHWESTERN CALIFORNIA:

NOTES ON THE GRASSES AND FORAGE PLANTS AND RANGE CONDITIONS.

BY

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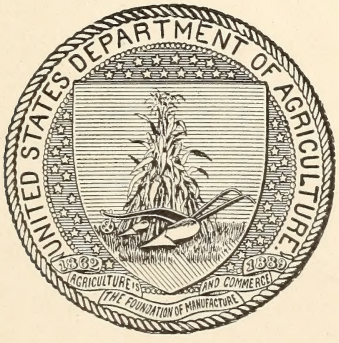
PREPARED UNDER THE DIRECTION OF THE AGROSTOLOGIST,
GRASS AND FORAGE PLANT INVESTIGATIONS.



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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., November 23, 1901.

SIR: I have the honor to transmit herewith a paper entitled Stock Ranges of Northwestern California: Notes on the Grasses and Forage Plants and Range Conditions, and respectfully recommend that it be published as Bulletin No. 12 of the Bureau series. The paper was prepared by Mr. Joseph Burtt Davy, assistant botanist of the Agricultural Experiment Station, University of California, and was submitted by the agrostologist.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

PREFACE.

This report entitled Stock Ranges of Northwestern California: Notes on the Grasses and Forage Plants and Range Conditions, was prepared under my direction by Mr. Joseph Burtt Davy, assistant botanist of the Agricultural Experiment Station of the University of California. Mr. Davy, under commission from the United States Department of Agriculture, through this Office, dated March 24, 1900, made a very thorough investigation of the grasses and forage plants of northwestern California, a region whose forage resources have not heretofore been carefully studied. The report contains a comprehensive account of the whole region, its physiographic and climatic conditions, and all the features bearing upon the forage problem. The information it contains will be of use to ranchmen and dairymen and all those interested in the stock industry, and will be found of special value to those living within the region which it covers. In addition to the presentation of this report, Mr. Davy collected a large and valuable series of specimens of the native grasses and other plants which supply more or less grazing, and a set of these specimens has been added to the collections of the Office.

Mr. Davy wishes to express here his sincere thanks to Dr. Walter C. Blasdale for invaluable assistance rendered in the collection and preparation of specimens, for taking and preparing the photographs which illustrate this report, and for help in many other ways. Without this assistance the investigation could not have been successfully accomplished.

F. LAMSON-SCRIBNER,
Agrostologist.

OFFICE OF THE AGROSTOLOGIST,
Washington, D. C., November 25, 1901.

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STOCK RANGES OF NORTHWESTERN CALIFORNIA: NOTES ON THE GRASSES AND FORAGE PLANTS AND RANGE CONDITIONS.

INTRODUCTION.

PHYSICAL FEATURES OF THE REGION.

Northwestern California as here defined includes the counties of Lake, Mendocino, Humboldt, Trinity, Del Norte, and the portion of Siskiyou lying west of the California and Oregon Railroad. It is approximately bounded by lines drawn at 39° and 42° north latitude, and 122° 30′ and 124° 30′ longitude west of Greenwich. (See Map I.)

It is a fairly well-defined topographical area, bounded on the east by the inner Coast Range Mountains and on the west by the Pacific Ocean. It covers the whole of the drainage basins of the Eel, Mad, Trinity, Lower Klamath, and Smith rivers and the smaller streams along the coast north of the Gualala River. On the south it extends beyond this naturally delimited area to include Lake County and the southern boundary of Mendocino County, thereby taking in the drainage basin of Clear Lake and the headwaters of Russian River.

AGRICULTURAL SUBDIVISIONS.

This region is divisible into seven agricultural areas, which are more or less clearly marked topographically, climatically, and phytologically. They are:

1. The Interior Plateau Belt, dissected into long ridges separated by deep canyons, some of them running in a more or less northwesterly direction, other and shorter ones almost due west. This belt is bounded on the west by the redwood forest and on the east by the Mayacama, Yallo Bolley, and South Fork mountains. Lying at a higher altitude, 2,000 to 4,000 feet, it enjoys a warmer summer temperature and less moisture than the Coast Bluff belt; also its soil is heavier, containing more clay and less sand. With the exception of a few mountain valleys included within its limits this is almost exclusively a pastoral area.

2. The Coast Bluff Belt, a narrow stretch of agricultural and pastoral land varying from 1 to 3 miles in width, and occupying a mesa or

bench between the shore line and the summit of the first mountain ridge, which is about 1,600 feet high. This ridge marks the western edge of the redwood belt. For the most part this belt is elevated some 50 or more feet above the sea, but at Humboldt Bay and Crescent City it has been eroded almost to sea level, there forming a large and very fertile flood plain. It is subject to heavy summer fogs, enjoys a more equable summer climate and a greater amount of moisture than is found in the interior, and is relatively cool. The soil is considered poor except at a few points; it is light, being abundantly charged with drift sand.

3. The Redwood Belt, lying between and parallel with the coast bluff belt and the interior plateau, and consisting of rough ridges, separated by narrow V-shaped canyons. It is covered by a more or less dense growth of redwood (*Sequoia sempervirens*), and is a climatic and phytological rather than a geographical area, embracing and being limited to the redwood forest. It runs almost the whole length of the coast of northwestern California, apparently being interrupted in only one or two places, and lies for the most part away from the coast line, sheltered from cool and violent winds behind a ridge which runs nearly parallel with the shore. Scattered redwood trees are but rarely found outside of this belt, which comprises the forest proper. The heavy summer sea fogs, drifting high overhead across the narrow bench of bluff land, are intercepted in their course by the trees on the summits of the ridges, or, when they lie low, roll along the broad river valleys and more numerous narrow canyons opening into the redwood forest, saturating the tree tops, and by their means also the soil below, with abundant moisture. The actual conditions which delimit this redwood belt are not at present clearly understood, but climate appears to have been, above any other evident physical cause, a potent factor in the development of the forest. The soil conditions appear to be generally comparable to those of the plateau canyons, except for the additional amount of humus due to the presence of the trees.

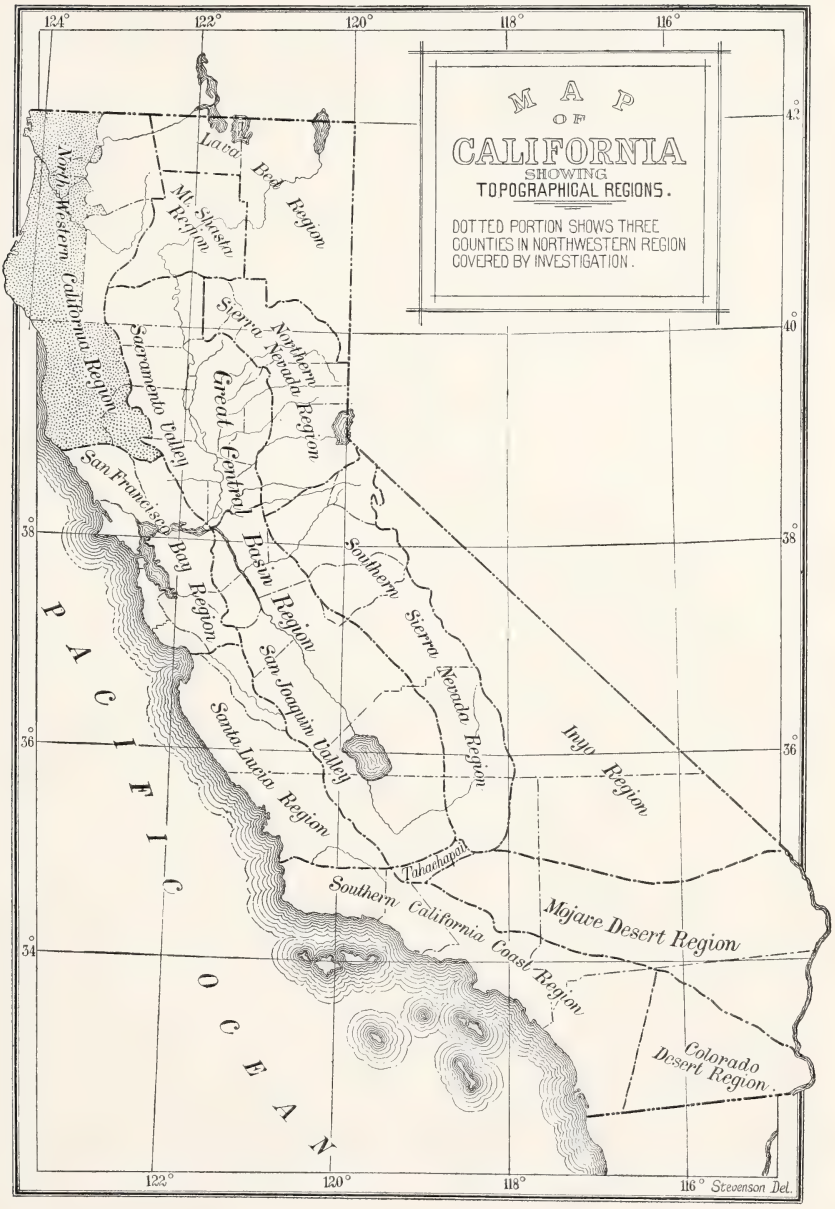
4. The headwaters of the Russian River, forming a connecting link between the distinct topographical region of northwestern and that of western middle California, otherwise called the San Francisco Bay region, to the latter of which it strictly belongs. It is included in this report because it lies within Mendocino County and because it was the starting point of the expedition.

5. The drainage basin of Clear Lake, for the most part a stony and mountainous region, walled in on all sides, and with little level land. Its resources are mainly pastoral, though the lake is fringed by some rich farming and fruit land.

6. Trinity County, an isolated mining region, almost walled in by high mountains, and including the headwaters of Trinity River. Scarcely anything is known of the botany of this very distinct topo-

FIG. 1.—HUPA VALLEY FROM THE MOUNTAINS, LOOKING SOUTH.

FIG. 2.—SUMMIT OF THE PLATEAU ABOVE HARRIS, LOOKING WEST, SHOWING THE UPLAND RANGES, THE MOST IMPORTANT PASTORAL AREA IN THE REGION.


MAP
OF
CALIFORNIA
SHOWING
TOPOGRAPHICAL REGIONS.
DOTTED PORTION SHOWS THREE COUNTIES IN NORTHWESTERN REGION COVERED BY INVESTIGATION.
124°
122°
120°
118°
116°
42°
40°
38°
36°
34°
Lava Beds Region
Mt. Shasta Region
North Western California Region
Sacramento Valley
Sierra Nevada Region
Northern
Great Central Basin Region
San Francisco Bay Region
Southern Sierra Nevada Region
San Joaquin Valley
Santa Lucia Region
Inyo Region
Tehachapi
Southern California Coast Region
Mojave Desert Region
Colorado Desert Region
PACIFIC OCEAN
Stevenson Del.

graphical area, but the collections of Chestnut and Drew[a] indicate that it may be phytologically distinct from the section west of the South Fork Mountains. A collection of plants, including several grasses, has been made by Miss Eastwood during the summer of 1901.

7. The Siskiyou, Scott, and Salmon mountains. Collections of grasses from this region were made by Mr. T. H. Gilbert in the summer of 1899 and Mr. H. P. Chandler in the summer of 1901, but have not yet been completely worked up.

Only the first four of these subdivisions are discussed in the present report. On account of the brevity of the flowering season of grasses in California, of the extent of the region included within the above-described boundaries, and of its general inaccessibility and the cost of travel in a mountainous and thinly populated country, it was found impossible to visit all of the subdivisions of the region. Those portions most prominently devoted to dairying and cattle raising were therefore selected for investigation. They include a large portion of Mendocino and Humboldt counties and the narrow strip of coast line in Del Norte County.

These three are the most northerly coast counties of California, and together cover an area of about 8,513 square miles. On the accompanying map (I) their position is indicated by the dotted portion, the heavy lines nearest to it on the east and south marking the inland boundaries of the whole region of northwestern California.

TOPOGRAPHY.

In a paper on the "Geomorphogeny of the coast of northern California,[b] Prof. A. C. Lawson says of the topography of Sonoma, Mendocino, and Humboldt counties:

> The coast ranges of northern California comprise, besides the mountains proper, which, except for isolated peaks, are distant from the ocean, a broad coastal tract which may be said to be devoid of true mountain topography. This tract is clearly a dissected plateau, and impresses itself as such upon the observer very forcibly when viewed from any point not lower than its general level. (See Plate I.) The plateau is now represented only by long, roughly level-topped ridges, which are separated from one another by long, narrow valleys. At the heads of the streams which drain the valleys the ridges are frequently confluent. The ridges have a remarkable constancy of general altitude. The observer stationed on one which is slightly more commanding than the rest beholds a vast expanse of country, with no prominent profile against the sky throughout the tract in Sonoma and Mendocino counties. Ridge succeeds ridge in seemingly endless sequence, and to an observer overlooking the foreground the general effect of the ridges falling away in perspective is that of a plain. So situated he can easily imagine the intervening valleys filled flush with the crests. The plain so restored would be neither level nor even. It would be a sloping plateau of low relief. Along the front of this plateau, where it overlooks the ocean, its general

[a] Drew, Elmer R. Notes on the Botany of Humboldt County, Cal.: Bul. Torr. Bot. Club, XVI, 147–152. 1889.

[b] Lawson, Prof. A. C.; Geomorphogeny of the coast of northern California: University of California, Dept. of Geology, Bul—241–272, Nov. 1894.

altitude is about 1,600 feet. Back from the coast, where it passes into the higher and more mountainous tract of central and eastern Mendocino County, it has an elevation of about 2,100 feet. On entering Humboldt County several sharp peaks rise abruptly above the general level of the dissected plateau to altitudes of from 3,000 feet to 4,000 feet, but remnants of plateau clearly encircle these and give their middle slopes a distinctly terraced aspect.

It is evident that northward of the fortieth parallel of latitude the forces which effected the evolution of the original plain have made but little headway as compared with the coastal region to the south of the same line, or they had been interrupted in their work by orogenic disturbances. The plain in Humboldt County represents no broad expanse, as in Mendocino and Sonoma counties, but may be followed in between an open cluster of mountain peaks and ridges. The present reconnaissance establishes the fact of its extension as far as the Bear River ridge. It doubtless extends up the coast, however, far beyond the limit set to (my) exploration.

* * * * * * *

That this great dissected plateau represents an ancient peneplain which has been uplifted from a nearly base-leveled condition to its present altitude seems beyond question. The rocks of which it is composed are of various ages, of various degrees of hardness, and have been throughout the region so disturbed that their original horizontal condition is practically nowhere to be found. The surface of the ancient peneplain consists of the beveled edges of the upturned strata. On the summit of one of the characteristic ridges of the plateau between Usal and Kenny numerous waterworn pebbles were found at an elevation of about 1,600 feet, which can only be interpreted as remnants of the stream gravels of the ancient peneplain.

CLIMATOLOGY.

The following data are compiled from the annual summaries of the Weather Bureau:[a]

The only stations within the region from which we have any climatological data are:

In Mendocino County; Point Arena and Fort Bragg on the coast, Ukiah and Cahto in the interior.

In Humboldt County; Upper Mattole, Cape Mendocino, Humboldt Light and Eureka on the coast, Hydesville in the Interior.

In Del Norte County; Cresent City on the coast.

From the interior plateau belt, proper, we have no data.

Temperature.—The mean annual temperature for the three years 1897–1899, as recorded in the annual summaries of the Weather Bureau, was 50 degrees F. The highest in 1899 was 108 degrees in the interior at Ukiah, on July 2 and other days, and 83 degrees on the coast at Crescent City on September 15. The lowest was 20 degrees at Ukiah on February 5, and 23 degrees at Crescent City on February 4.

The last killing frosts in spring were: February 5, at Ukiah; February 7, at Eureka; May 9, at Cahto; and June 19 at Crescent City. The first killing frosts in autumn occurred on October 14, at Crescent City; October 25, at Cahto; December 13 at Eureka and Ukiah.

[a] U. S. Dept. of Agriculture, Weather Bureau, California Section of the Climate and Crop Service. Annual Summaries for 1897, 1898, and 1899. San Francisco.

TOPOGRAPHICAL MAP OF NORTHERN AND MIDDLE CALIFORNIA.

The average dates of killing frosts are as follows: Last in spring, March 29 at Eureka, April 14 at Ukiah, and May 10 at Crescent City; first in autumn, November 1 at Ukiah, November 7 at Crescent City, and November 29 at Eureka.

Precipitation.—The total annual rainfall is invariably heavier in this portion of the State than in any other. Even in the drought years of 1897 and 1898 the annual rainfall exceeded 50 inches at Crescent City and 40 inches over almost the whole of Humboldt County. In 1899 the maximum was 86.55 inches at Crescent City. The following table, based upon the Government reports, shows the precipitation that may be expected each month:

Normal monthly precipitation.

Month.	Ukiah.	Eureka.	Month.	Ukiah.	Eureka.
January	7.82	7.48	August	0.01	0.16
February	5.28	6.47	September	.60	1.25
March	4.93	6.57	October	1.48	2.61
April	3.21	4.28	November	3.61	5.33
May	.92	2.99	December	6.84	7.66
June	.22	1.23			
July	.05	.10	Annual	34.97	46.13

The snowfall on the coast is usually small, 1.5 inches being reported for Upper Mattole and only a trace at Crescent City in 1898, 4 inches at the latter place in 1899, and none at Eureka. In 1898 Ukiah had 3 inches of snow, but in 1899 none. However, snow is reported to fall almost every winter on the upland ranges near Ukiah and on the plateau.

Prevailing winds.—During these three years the prevailing winds over the whole region are reported as from the northwest.

ITINERARY.

The forage conditions of this region were made the subject of an investigation by the writer, with the assistance of Mr. Walter C. Blasdale, in the summers of 1899 and 1900.

Three trips were made, of which the routes traversed are shown on Map III. The first trip occupied from May 23 to July 3, 1899, and embraced the interior plateau section. The stage road was followed from Ukiah to Eureka, a distance of about 183 miles, passing through Willits, Sherwood, Laytonville, Cummings, Harris, and Scotia. From Eureka the two mountain ridges were crossed to Hupa Valley, on the Trinity River, about 50 miles distant. From Hupa a side trip was taken to the summit of the Trinity Mountains at Trinity Summit, about 7,000 feet altitude. From Hupa Valley the descent of the Klamath River from Martins Ferry to Requa on the coast, a distance of 55 miles, was made by Indian canoe. From Requa the stage road was followed to Crescent City and Smith River, the return trip to San Francisco being made by steamer.

The second trip was taken alone and occupied from July 15 to August 10, 1899. The route followed the coast-bluff belt from the Gualala River to Kenny's, thence inland to Briceland and Garberville, and down the Eel River Valley to Ferndale. From Ferndale a trip was taken to Cape Mendocino. The return to San Francisco was again made by steamer, this time from Eureka.

A third and supplementary trip was made in the summer of 1900, this time also alone, the route crossing the redwood belt twice, the first time between Willits and Fort Bragg, the second from De Haven Creek to Branscombs. Two days were also spent in Lake County, the road from Ukiah to Upper Lake, by way of Blue Lakes, being taken, returning by way of Lakeport and Highland Springs to Hopland.

RANGE CONDITIONS.

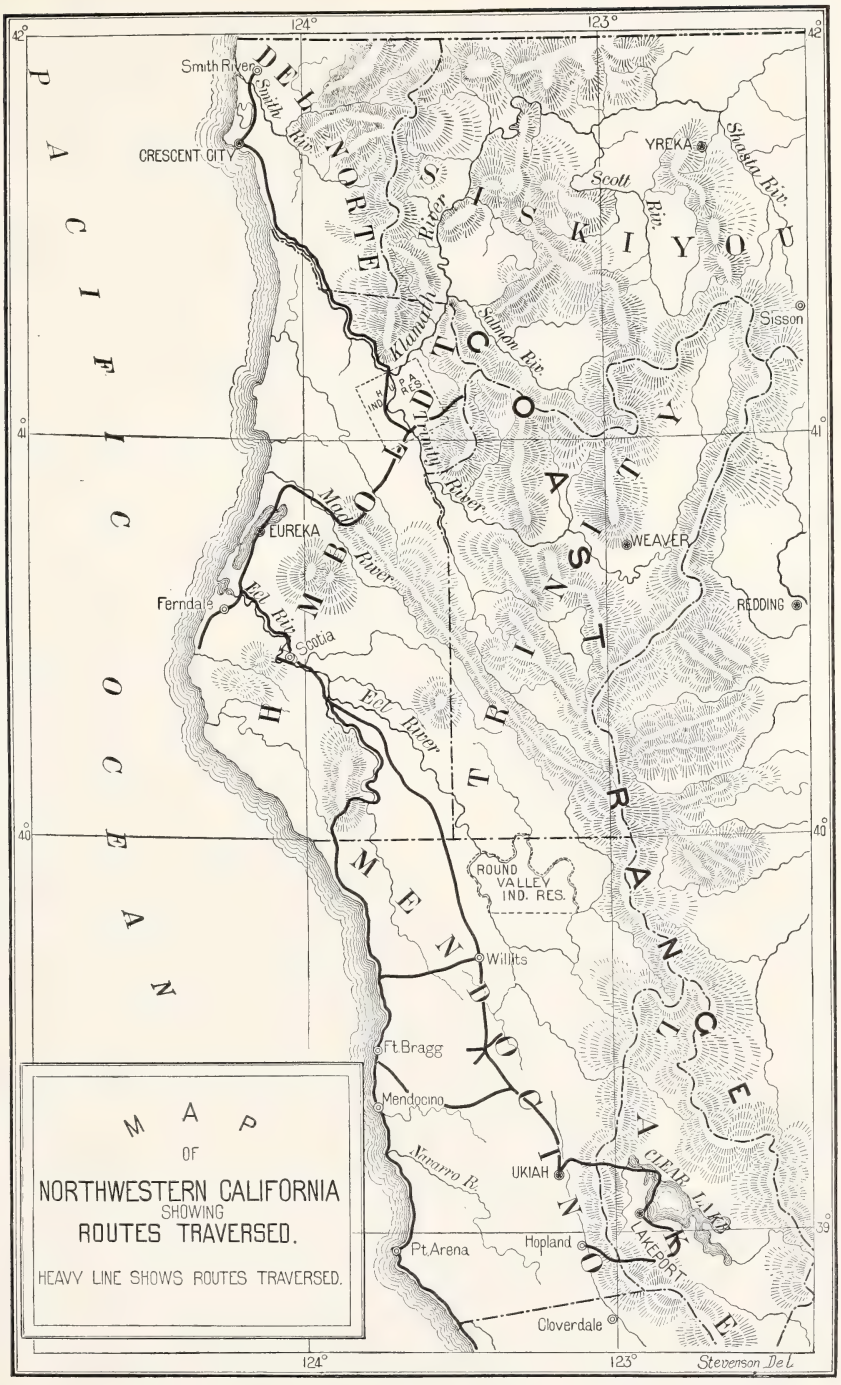
THE INTERIOR PLATEAU REGION.

MOUNTAIN VALLEYS.

Numerous mountain valleys (Pl. I, fig. 1) occur in Mendocino County, on either side of Walker Mountain, the watershed which separates the Russian River and Eel River drainage basins. South of the divide lie Ukiah, Walker, Potter, and several other small valleys whose streams run southward into the Russian River. North of the divide are Little Lake, Sherwood, Round and Long valleys, on the headwaters of Eel River. Hupa Valley is on the Trinity River, in Humboldt County. Some of these valleys lie, like glacial basins, at the headwaters of their streams; others occur a few miles lower down, at slightly lower altitudes, and are connected with the first by narrow canyons. On account of the narrowness of their outlets, some of these valleys are not infrequently flooded at the time of the winter rains. The highest have an altitude of about 2,300 feet above sea level.

Temperature.—Although intensely hot days occur at times, the climate is usually cool and humid, except, perhaps, in Hupa and Round valleys, on account of heavy summer fogs which creep up from the ocean and hang in the surrounding tree tops. Long, unbroken hot spells are almost unknown. The nights are cool. In Sherwood Valley it is said that frosts occur every month in the year. Unfortunately we have only the most meager meteorological data from this section of the region, but observation shows that the rainy season continues later into the summer than it does in the vicinity of San Francisco, and that the rainfall is probably much heavier in the former than in the latter region. A little snow falls each winter.

Water supply.—Perennial springs are abundant, flowing freely from all the higher wooded ridges. Every meadow has its own creek, which in most cases has cut a channel to a depth of from 3 to 6 feet through the soft alluvial soil. (See Pl. II.)


42°
124°
123°
41°
40°
39°
PACIFIC OCEAN
DEL NORTE
SISKIYOU
HUMBOLDT
TRINITY
MENDOCINO
LAKE
Smith River
Smith Riv.
CRESCENT CITY
YREKA
Shasta Riv.
Scott Riv.
Klamath River
Salmon Riv.
Sisson
Trinity River
EUREKA
Mad River
WEAVER
Ferndale
Eel Riv.
Scotia
REDDING
Eel River
ROUND VALLEY IND. RES.
Willits
Ft. Bragg
Mendocino
Navarro R.
UKIAH
CLEAR LAKE
LAKEPORT
Pt. Arena
Hopland
Cloverdale
MAP
OF
NORTHWESTERN CALIFORNIA
SHOWING
ROUTES TRAVERSED.
HEAVY LINE SHOWS ROUTES TRAVERSED.
Stevenson Del

Soils.—In Little Lake Valley and Sherwood Valley the soil appears to have been formed by delta deposition in the bed of small mountain lakes; it consists of a moist, sandy loam, which is deep, exceedingly fertile, and apparently well adapted to general farming.

The following report of analyses of soils from localities about 2 miles northeast of Willits (probably in Little Lake Valley) were made in 1891 by Dr. R. H. Loughridge, of the Agricultural Experiment Station at Berkeley.[a] The samples were received through Mr. S. F. Swortfiguer, of San Francisco, who says:

A large part of the land from which the samples were taken lies about 22 miles inland from the ocean, and is well sheltered on the west from the coast winds by intervening ridges covered with a heavy growth of redwood timber, and from cold winds from the north by a heavy growth of pine [probably *Pinus sabiniana* or *P. ponderosa*] and fir [*Pseudotsuga taxifolia*]. The elevation is about 2,000 feet above sea level.

The samples were taken to a depth of 22 inches.

Analyses of soils near Willits, Cal.

Constituents.	No. 1459. Valley soil (Home ranch).	No. 1460. Hill soil (Hammond ranch).	No. 1461. Soil elevation 2,000 feet (Young ranch).
Coarse materials > 0.5 mm	50.00	50.00	50.00
Fine earth	50.00	50.00	50.00
ANALYSIS OF FINE EARTH.			
Insoluble matter	55.55	59.50	69.20
Soluble silica	13.56	9.33	5.57
Potash (K_2O)	.76	.61	1.14
Soda (Na_2O)	.04	.05	.09
Lime (CaO)	.29	.30	.38
Magnesia (MgO)	1.03	1.02	1.61
Manganic oxid (Mn_3O_4)	.06	.04	.05
Ferric oxid (Fe_2O_3)	8.80	12.77	5.53
Alumina (Al_2O_3)	11.95	6.97	9.74
Phosphoric acid (P_2O_5)	.04	.06	.06
Sulphuric acid (SO_3)	.04	.03	.04
Water and organic matter	7.45	9.25	6.30
Total	99.57	99.93	99.71
Hygroscopic moisture (absorbed at 15° C.)	5.27	5.89	4.47

These soils, while of excellent quality as a whole, are rather poor in lime, as compared with others of the State, though not deficient. They share with other California soils a large proportion of potash and a rather low one of phosphoric acid. The latter is doubtless the first deficiency that will make itself felt, unless it be that of humus, which (as the soil was taken to 22 inches depth, instead of 6 or 8) could not be determined in the samples.

As regards field crops, roots and not grain will hold out longest on these soils. They all contain so much gravel that cultivation will not be difficult, and roots, with fair tillage, will find no difficulty in developing. Their moisture absorption is satisfactory.

[a] University of California Agricultural Experiment Station: Report for 1891–92, pp. 31–32; report of analyses of soils from near Willits, Mendocino County.

As to fruits, grapes, apples, and pears would seem the best suited to the soils; stone fruits will doubtless do well also, but with heavy crops will soon require fertilization with phosphates. The hill soil would seem especially adapted to peaches and high-class wines and almonds if the climate permits. Apricots should do well, especially on the Young ranch, and on the valley land if not liable to late frosting.

Judging by the large size reached by the Madroñe (*Arbutus Menziesii*) and other forest trees on these soils, a similar development and longevity may be looked for in the trees adapted to the soil, where its depth is correspondingly great. With this proviso the English walnut in the valleys, the Italian or Japanese chestnut on the hills, would be likely to do well.

Round Valley, the largest of the valleys, has an elevation of about 1,600 feet; it is said to be about 7 miles in diameter in any direction, and to contain a soil which is a rich loam, somewhat gravelly on the west side, and somewhat adobe-like on the east. It is said to be very fertile and to produce excellent crops of wheat, which, however, can at present be grown only for local consumption, on account of the inaccessibility of a good market. The valley contains about 25,000 acres of agricultural land. The rainfall varies from 38 to 60 inches per annum and the mean annual temperature is 60° F. "In 1898 the valley exported 8,000 hogs, 3,000 beef cattle, 100 mules, and 2,500 mutton sheep; it also produces large quantities of hay and an average of 150,000 bushels of grain per annum."[a]

Little Lake Valley is principally employed in grain raising, producing about 60,000 bushels annually. The average yield is said to be 20 bushels of wheat, 35 of barley, and 40 of oats.

The soil of Hupa Valley (Pl. I), an Indian reservation on the Trinity River, is very gravelly, dry, and poor. Unlike Little Lake, Sherwood, and Long valleys, Hupa is situated many miles from the headwaters of its main stream, and the soil is evidently more nearly that of a river gravel bar than of an alluvian mountain valley. It is poorly adapted to the production of agricultural crops, returning only a sparse yield of grain.

Agricultural products.—Small quantities of wheat, fruit, vegetables, and poultry are raised for local consumption. The principal export products are cattle, sheep, wool, and hogs.

Oats, of which red, black, and white varieties are grown, but principally the first named, together with a little wheat, is the principal hay crop. It is said that barley does not succeed well in these high valleys, yielding only about two tons of hay to the acre, as compared with five tons sometimes obtained in Ukiah Valley, south of the divide. Some timothy hay is grown in Sherwood and Long valleys, yielding about three tons to the acre; and red-top (*Agrostis alba*) is reported to be successfully cultivated in a few places. It is said, however, that both timothy and red-top "run out" in a few years, which may be due to the practice of pasturing too long after the rainy sea-

[a] Ukiah Dispatch-Democrat.

FIG. 1.—A MOUNTAIN MEADOW, SHERWOOD VALLEY.

FIG. 2.—THE BORDER OF THE MEADOW.

son commences. In Long Valley it is found that stock can be fed on timothy aftermath without injury to the crop, provided they are taken off when the first rains fall.

A small quantity of alfalfa hay is produced in Long Valley. In this part of the State there is still a great deal of prejudice against it. It is considered "too soft" for either horses or beef cattle, and is fed only to cows and hogs. Much of the dissatisfaction is undoubtedly due to feeding alfalfa alone. The addition of good straw to the ration (in the proportion of one-half straw to one-half alfalfa) will make a well balanced and highly valuable feed. Moreover, alfalfa is not well adapted for pasturing, but should be soiled or fed as hay or silage. It is possible that the summer is too short in this region and the temperature not sufficiently high for the profitable cultivation of alfalfa.

The cool climate, fertile soil, abundant supply of running water and of timber for fuel and fencing, point to these mountain valleys as being ideally adapted to dairying. Nothing is done in this line, however, beyond the supply of the small local demand, on account of the distance from a shipping point and the cost of transportation by rail. From Fort Bragg, the nearest coast port, Sherwood Valley is distant about 20 miles, over an exceedingly rough, mountainous road with a descent of some 2,000 feet. The distance to Ukiah, the nearest railroad depot, is about 35 miles, the road crossing two steep mountains. A creamery has recently been started in Sherwood Valley, the output in 1899 being over 20,000 pounds, most of which went to the Mendocino Hospital. A creamery has been established in Potter Valley during the past year.

The wild meadows and pastures.—We can find no record of the condition of vegetation in these valleys before farming operations were commenced. An approximate idea of the early native flora can be gained, however, from the present vegetation of Sherwood Valley, where but little cultivation has been practiced, and where many of the meadows appear never to have seen the plow. Nevertheless, it is certain that the quantity of valuable native species has been materially reduced by heavy grazing in the fifty-odd years of occupation by white settlers, thereby increasing the relative abundance of less appreciated species. Several weedy plants have been naturalized within recent years. Mr. Sherwood, who settled in 1853 in the valley which bears his name, and who was the first white settler there, took the writer to a point some distance from his house to point out danthonia (*Danthonia californica*) as the grass which was the most abundant on hillside and valley floor and which formed the favorite and most nutritious forage plant when he first brought cattle into the valley. This grass is now scarce in the vicinity.

In Sherwood Valley the three grasses now prevalent are: (1) *Bromus racemosus commutatus;* (2) *B. hordeaceus glabrescens;* (3) *Holcus*

lanatus (Velvet-grass, locally called "mesquite.") These three are not indigenous, but have become naturalized from Europe as weeds, and occupy the place of native plants probably of greater value.

Other naturalized species commonly met with are: Soft chess (*Bromus hordeaceus*), silvery hair-grass (*Aira caryophyllea*), small barley-grass (*Hordeum maritimum gussoneanum*), which is abundant in spots where other grasses do not thrive, and rat-tail fescue, locally called squirrel-tail (*Festuca myuros* var. *ciliata* and var. *sciuroides*). Broncho-grass (*Bromus maximus gussoni*) is occasionally met with, but at present only sparingly. If conditions prove as favorable to its development here as in the San Francisco Bay counties, however, it is likely to become a prevalent and troublesome weed. At present it is said that stock do not like it, even while young, soft, and tender, before it heads out, and after heading out its long awns are objectionable. Red-top (*Agrostis alba*) and timothy (*Phleum pratense*) have been introduced as forage plants and are occasionally met with, but have almost entirely "run out."

The only native grasses met with in the meadows are noted here. Tufted hair grass (*Deschampsia cæspitosa*) forms large tussocks and may, perhaps, be of some use for grazing, but is valueless for hay as its scattered and tufted habit of growth renders it almost impassable with a mowing machine; it is not considered of much value by the farmers. Slender hair grass (*Deschampsia elongata*) seems to occur in two or three forms. One of these is very common in wet places, and another equally abundant in drier spots. An Agrostis (*A. exarata microphylla*) is common in wettish places. Occasional specimens of meadow barley grass (*Hordeum nodosum*), danthonia (*Danthonia californica*), and prairie June grass (*Koeleria cristata*) also occur. California fescue (*Festuca californica*) is quite common along the borders of streams near the edge of the woodlands, forming large and handsome tussocks, but as a forage plant it is somewhat harsh and coarse. Two or three species of sedge and a rush are very common, but probably have little nutritive value. Blue canary-grass (*Phalaris amethystina*) occurs along the edge of the redwood forest. In the streams and swamps a species of *Pluropogon* and *Panicularia fluitans* are quite common, and slough-grass (*Beckmannia erucæformis*) is sometimes met with; the latter is reported as having been very plentiful in the sixties.

Of forage plants other than grasses and sedges the following native clovers are quite common: *Trifolium dichotomum* var., *T. microdon*, *T. barbigerum*, *T. bifidum decipiens*, *T. microcephalum*, *T. wormskjoldii* var., *T. variegatum*, and *T. tridentatum*. *T. depauperatum* and *T. longipes* var. are also met with, though only sparingly. As a forage plant, the bull clover (*T. wormskjoldii* var.) is the most valuable species, in damp places sometimes growing 2 or 3 feet high, and being a favorite food of both cattle and Indians, who eat it raw—

leaves, stems, flower heads, and all—like a salad. *T. longipes* var. forms tufts of several stems from a stout, perennial rootstock, and is worth experimental culture as a forage plant. *T. variegatum* is common in wet places and is closely eaten by cattle; it is one of the most promising native species. *Lotus pinnatus* is a common leguminous plant of wet places, and may be of some value as forage. Rib grass (*Plantago lanceolata*) has become naturalized, but is not yet abundant.

Though the various grasses, sedges, and rushes together form the largest proportion of the meadow vegetation, and native clovers are plentiful, other and less valuable plants abound, occupying space which could be filled with species of greater economic value. A buttercup (*Ranunculus occidentalis*) forms large yellow patches in the open meadow, while in marshy spots the camass (*Camassia esculenta*) produces masses of bright blue flowers in early summer. A species of *Veratrum*, not in flower at the time of our visit, is quite common, and is reported as being poisonous to stock. A species of *Orthocarpus*, with yellow flowers, is the prevalent meadow weed, and forms, together with blue-eye grass (*Sisyrinchium*) and camass, brilliant masses of color, gold and blue, in the months of May and June. Species of *Polygonum*, *Eunanus*, *Collinsia*, *Lupinus*, *Agoseris*, *Zygadenus*, *Achillea*, and *Lotus* also occur in varying abundance. Sorrel (*Rumex acetosella*) has found its way into Hupa Valley, and is met with elsewhere in the region. It is one of the most pernicious weeds.

Forage value of the wild meadows.—The composition of the herbage in these wild meadows does not give indication of high forage value; the grasses are for the most part weedy species, producing comparatively little foliage. The hay produced is poor in quality and is not eaten greedily by stock. Much of it is trampled under foot as waste. Mr. C. W. Bradford, of Sherwood, states that about 3 tons of wild hay to the acre may be considered an average yield in the valley, and that about 50 head of cattle can usually be pastured for some five months on 100 acres of valley pasture. When danthonia and native clovers were the prevalent species, the carrying capacity of meadow and pasture was probably much greater. On account of the abundant water supply and peculiar climatic condition enjoyed by these mountain valleys there are few places in the State of California which give better promise for the formation of good permanent meadows and pastures. With the evidence before us of what is actually being accomplished in the Eel River Valley, in Humboldt County, there is no apparent reason why, with the cultivation of the best adapted and most nutritious forage plants, at least 5 tons of hay per acre should not be raised, and the carrying capacity of 100 acres be raised from 50 head of horned stock for five months to 100 head for twelve months.

Improvement of pasture and meadow.—In order to produce such a desirable condition, the work of renewing meadow and pasture must

be undertaken in a practical manner and one giving promise of success. The mere scattering of seed of a desirable species without preparation of soil or further attention is not likely to afford material, if any, improvement. It should also be borne in mind, in this connection, that the humidity of atmosphere and soil are important factors in the problem, and that if by the destruction of the forests and woodlands, which attract moisture, induce precipitation, and conserve the springs from which streams and rivers arise, the valleys, at present moist and fertile, are reduced to the condition of aridity met with in some other regions of the State, the chance of increasing the stock-carrying capacity will be destroyed.

To get rid of the tussocks formed by tufted hair grass and California fescue, to remove weeds, and to give the new forage plants a fair chance, the ground should be plowed in the spring to a sufficient depth to bury the turf thoroughly. It should then be allowed to summer fallow for a period, in order that the sod may rot thoroughly. The surface will require harrowing during the summer, probably several times, in order to destroy successive crops of annual weeds and to kill out the roots of perennial sedges and rushes. Sowing should be performed as early in the fall as possible, that the seed may benefit by the warm soil and the full rainfall of the growing season.

The preparation of a permanent pasture is greatly facilitated if a nurse crop of wheat, barley, or oats is grown, as it protects the young grasses during spells of north wind, frost, etc. It also utilizes the soil while the other plants are getting a start, and is of great value in keeping weeds in check. This nurse crop is preferably grown for soiling, rather than for hay or seed, as otherwise it shades the young plants of the permanent crop for too long a period and takes too much nutriment out of the soil. For the same reason only a thin sowing of grain is made, half of the usual quantity of seed being considered quite sufficient. In some places rye or wheat are considered the most desirable nurse crops. Oats occupy the ground too long, it is claimed, and are too easily "lodged" to be satisfactory.

If the plowing up of the wild meadows is considered too expensive or is impracticable, the simpler but much less satisfactory method of sowing new grasses among the old may be resorted to. In this case only about one-third of the seed required for a new pasture will be needed. The pasture must be thoroughly harrowed at the time of the first fall rains in order to preserve a seed-bed in which the new seeds can germinate.

In the East and elsewhere it is found advantageous in the preparation of a permanent pasture to sow a mixture of different species of grasses instead of only one kind, for the following reasons: Some of the best forage grasses do not make a crop until the second or even the third year; others, while in themselves valuable, do not stool-out or cover the ground completely, so that other and low, prostrate spe-

cies are needed to fill the spaces between them. Some species make an early and some a much later growth; some flower early and others late, and it adds much to the value of a permanent pasture if the different species composing it mature at different periods.

A total of from 30 to 40 pounds of seed per acre is recommended for new pastures if the best results are to be obtained. It is better to err on the side of too much than too little seed; for, if the ground is not well covered at first, weeds will quickly occupy the bare spaces, and they are much harder to eradicate when once established than to keep out from the start. Experience proves that "thicker seeding more than repays its extra cost."

Forage plants recommended for trial.—Only experimental culture on the spot can finally determine which species are best adapted to any one locality or soil; nevertheless, much waste of time, effort, and expense can be avoided by studying the results already obtained from experiments conducted elsewhere. For several years the collection and study of forage plants has been made a prominent feature of the work of the Agricultural Experiment Station of the University of California, at Berkeley. These experiments have shown that, while many forage plants of great value elsewhere are not adapted to the climatic conditions of California, there are several which can be successfully cultivated.

The following list includes the more nutritious of those species which experience proves most likely to be successful: Orchard grass (*Dactylis glomerata*), reed fescue (*Festuca arundinacea*), many-flowered millet grass (*Oryzopsis miliacea*), tall oat grass (*Arrhenatherum elatius*), awnless brome grass (*Bromus inermis*), red fescue (*Festuca rubra*), rescue grass (*Bromus willdenowii*), timothy (*Phleum pratense*), meadow foxtail (*Alopecurus pratensis*), creeping bent or fiorin (*Agrostis alba stolonifera*), Italian ray-grass (*Lolium italicum*), red clover (*Trifolium pratense*), perennial white clover (*Trifolium repens*), alsike clover (*Trifolium hybridum*).

Orchard-grass has already been tried with some success between Willits and Sherwood, in shady places. It is said to start more rapidly and to make a better growth if the ground is burned over before sowing. It is grown successfully as a forage plant in the vicinity of Eureka, and has become naturalized near Berkeley and near Crescent City.

Timothy has been tried in Sherwood Valley and Long Valley, and is still used as a hay crop in some places. It is not generally liked, however, on account of a bad tendency to "run out" after a short time. This tendency is probably not inherent, however, and may be caused either by overstocking or by the practice of pasturing late, after the ground has been softened by heavy rains, a method which causes injury to the roots, especially where there is an absence of thick turf. Timothy has become naturalized in northwestern

California, at Requa, Crescent City, and elsewhere, and it is evident, therefore, that it is not unsuited to the climatic conditions of the region.

Tall oat grass, on account of its phenomenally rapid development, is useful as a nurse crop for orchard grass and other species of comparatively slow growth. Reed fescue, many-flowered millet grass, awnless brome grass, and rescue grass have been grown successfully at Berkeley and elsewhere in the State. Red fescue and creeping bent are valuable as "bottom grasses," producing a large amount of tender, succulent herbage close to the ground. Italian ray-grass and the red, white, and alsike clovers are extensively cultivated as forage plants in the Eel River Valley.

THE UPLAND RANGES.

The most extensive open ranges of the region are found in the interior, on that portion of the plateau lying east of the redwood belt, and on the adjacent mountain slopes. The long ridges into which the plateau has been eroded vary in altitude at their inland end from about 2,000 to 4,000 feet, while the peaks of the ridge forming its eastern boundary attain a height of 8,000 feet in Mount Linn and 9,000 feet in Mount Eddy.

The view from the higher ridges is extensive; on the western horizon lies the ocean as a background. In the foreground ridge after ridge, heavily clothed with timber and divided by deep, dark canyons, slope gently to the shore line, some 18 miles away. Eastward the eye wanders over bleak grass-covered ridges, brown and dry under a scorching June sun, upward to the peaks of the South Yallo Bolley, 35 miles distant, which are about 7,000 feet in height and are still capped with snow in the month of June. At the bottom of deep canyons glimpses are occasionally caught of the broad bends of Middle Fork of Eel River.

The summits of the ridges and part of their western slopes are for the most part destitute of trees and brush, but densely clothed with grass. These open slopes form what is known as the open summer or annual range. (See Pl. III, fig. 1.)

In very few places is the ground too rocky and the soil too scant and poor to furnish abundance of grass. A few such places occur, however, and are covered with a dense growth of hardy shrubs, forming what is locally known as the "chaparral" or "chamisal." (See Pl. III, fig. 2.)

The eastern slopes and canyon bottoms are for the most part thickly covered with trees and underbrush—"browse," as it is called in the vernacular. These areas form the woodland or winter range.

Temperature.—On account of the altitude and exposure of the plateau its open ridges are subject to a low winter temperature, while in summer the days are intensely hot and the nights cool. The sum-

FIG. 1.—THE OPEN RANGE. SUMMIT OF THE PLATEAU ABOVE HARRIS, LOOKING EAST.

FIG. 2.—THE CHAPARRAL. WALKER MOUNTAIN, SHOWING THE STEEP, ROCKY, SPARSELY CLOTHED SLOPES, TOO BARREN EVEN FOR PASTURE.

mer temperature is not lowered, as on the coast and in some of the mountain valleys, by any sunshade in the form of banks of high fog.

Precipitation.—Over a large part of northern and middle California the rainy season, which is also the season of plant growth, commences with the latter part of September or early October and ends in April or May, varying with the year; the remaining three to five months constitute the dry or dormant season. In this particular section of the region, however, showers usually continue through May, and frequently into June, while August sometimes brings thunderstorms; in August, 1899, the rainfall varied in different localities from 0.10 to 1 inch. Mr. Bell, of Bells Springs, states that July is usually the only month in the year entirely free from rain. Mr. Tooby, of Harris, gives the mean annual rainfall at that station as about 40 inches. Reports from other points show that it is no less elsewhere, and possibly greater. Some snow usually falls on the plateau each winter. The open ridges are not subject like the coast bluffs to sea fog with its refreshing moisture.

Water supply.—Ephemeral springs are common on the ranges in the winter months, but quickly dry up with the advent of summer. Though excellent perennial springs occur here and there on the high ridges, they are usually far apart, and the dusty traveller may pass many a weary mile before finding a good camping place. Along the gulches and steep sides of the canyons, however, water is always to be found within accessible distance for stock. (See Pl. V, fig. 2). In such places the springs never dry up, doubtless on account of the protection and shade afforded by the timber and brush.

Soils.—The plateau soils consist, for the most part, of gravelly, yellow-brown, or reddish clays. A comparison of analyses of these and of the mountain valley soils is given on page 17.

From the nature of its physical conditions the upland range, which forms by far the largest portion of this section of the country, is never likely to be devoted to any other use than grazing, being unfitted for the general production of agricultural or timber crops. Whatever can be done, therefore, to improve the ranges will benefit one of the most important industries of the region.

At present the two industries of beef cattle and sheep raising are of about equal importance.

THE OPEN, SUMMER, OR ANNUAL RANGE.

As before noted, the open ranges occupy the summits and western slopes of the plateau ridges as well as the slopes of the higher mountains forming its eastern boundary.

Grasses and other forage plants.—The prevailing grasses are: (1) Rat-tail fescue, locally called "squirrel-tail" and "poverty grass" (*Festuca myuros ciliata*) small barley grass (*Hordeum maritimum gussoneanum*); (3) Soft chess (*Bromus hordeaceus* and var. *glabrescens*).

One or other of these naturalized and somewhat weedy foreign species forms the principal covering of every open range. The two first named are the most common, but as a rule they are not found in equal abundance on the same range; mile after mile is covered with small barley grass which predominates, almost, but not entirely, to the exclusion of rat-tail fescue; over another area the case may be exactly reversed, rat-tail fescue becoming the prevalent species. Both are weedy grasses, only considered valuable when young and tender; it is said that stock will not touch them after they "head out." Soft chess is considered highly nutritious when the seeds are ripe, stock eating the "heads" greedily; perhaps on this account it is less abundant than either of the others. The intermittent occurrence of the two first-named grasses may be due to their exotic origin, the species first introduced onto a range becoming the prevalent one. The fact that both are weedy grasses, and that neither one of them seems to be better adapted to range conditions than the other, nor is eaten by cattle after maturity, seems to indicate that in their case, at least, absence from certain places is not due to selection.

In addition to these three grasses the range feed is chiefly composed of alfilerilla (mostly *Erodium cicutarium*, *E. moschatum* being rarely met with), wild clovers, the prevailing species of the latter being *Trifolium bifidum decipiens*, *T. microcephalum*, and forms of *T. dichotomum*. "Bear Clover" (*T. furcatum virescens*) is common in certain situations, especially in moist "slidy" clay soils, and *T. variegatum* in moist, springy places. *T. cyathiferum* is only sparingly met with. *T. tridentatum* is especially abundant on ungrazed roadsides and ranges; its flowers have a pleasant, honey-like odor, and are very attractive to bees.

All of the above-named forage plants are shallow-rooted annuals, ephemeral in character and entirely dependent upon the opportunity to mature and scatter seed for the reproduction of their kind. Perennial herbaceous plants are not at all common, except in occasional and remote spots. The only perennial grasses noted on the dry, open hillsides were: Lemmon's bunch grass (*Stipa lemmoni*), California melic grass (*Melica californica*), a variety of red fescue (*Festuca rubra* var.), a variety of sheep fescue (*Festuca ovina* var.), danthonia (*Danthonia californica*), *Sitanion villosum*, *Elymus angustifolius*, and one or two species of *Poa*. On some of the more closely grazed ranges these perennial species are seldom seen, and occur in such small quantities as to be noticeable by their scarcity. Their rarity may be due to the fact that they are not, as a rule, turf-forming species, but tufted grasses ("bunch-grasses"), and therefore poorly adapted to withstand trampling and grazing by stock. Danthonia is reported to have been much more plentiful in former years—in fact, the most abundant forage plant, as it still is in some other parts of the State—and it is said to have gradually succumbed to sheep graz-

ing. It is considered, par excellence, *the* "bunch-grass" of the ranges, and sometimes grows so thickly as to form an excellent turf, giving promise of usefulness under cultivation for pastures, though too short for hay. *Trifolium scorpioides*, though only locally met with, is not uncommon in partial shade, under oak trees; it has a large, subfusiform perennial root, and may prove worthy of cultivation; its flowers are fragrant with a peculiar and characteristic odor. These ranges are designated annual ranges, because the forage plants, now abundant and characteristic, are annual species of short life, in contradistinction to the perennial ranges met with more frequently in the coast-bluff section, where danthonia, tufted hair-grass, and other perennial grasses still abound.

Weeds.—With the exception of the two prevalent annual grasses, rat-tail fescue and small barley grass, weeds are comparatively rare on the open ranges north of Cummings. Annual weeds are practically restricted to a few species of *Bœri* (the genus next best represented as regards number of individuals), *Lupinus*, *Achyrachœna*, *Agoseris*, *Microcarpus*, and a few others. Hawkbit (*Hypochœris glabra*) is establishing itself in places, and is likely to cause serious injury to the range pasture. "Tacalote" (*Centaurea melitensis*) is common and very troublesome on ranges near Ukiah; its prickly "burs" are apt to decrease the value of wool. Silvery hair grass (*Aira caryophylla*) and quaking grass (*Briza minor*) are common at Elk Prairie, and fine hair grass (*Aira capillaris*) occurs on Bair's sheep range at Redwood Creek; these plants are valueless for forage, and occupy space which should be filled by useful species.

Cocklebur (*Xanthium canadense*) is reported from the Traver range, near Cummings, a few plants having been noticed in 1876, which are supposed to have been introduced with cattle from the Sacramento Valley. According to Mr. Joseph Clarke, it has been exterminated. Broncho grass (*Bromus maximus gussoni*) first appeared on the Burns place, near Cahto, in 1879 or 1880, according to Mr. Clarke; it is now spreading throughout the region. If cut before the heads mature, this grass will make good silage, and at the same time its rapid spread will be checked.

Ribgrass (*Plantago lanceolata*) has become abundant on some ranges and is said to have reduced the carrying capacity from 4 or 5 acres to 10 acres to a head.

Perennial weeds are less frequently noticed, wild sunflower (*Wyethia*) being as common as any. Sorrel (*Rumex acetosella*), perhaps the most pernicious of all perennial range weeds, has found its way into some of the ranges.

THE PRAIRIES.

The word "prairie," as used in Mendocino and Humboldt counties, may be broadly defined as any small open space among the

timber, whether covered with grass or with dwarf brush. Along the coast of Mendocino County the name is applied to the areas of light, sandy "white-ash" soil covered with dwarf scrub and surrounded by timber. In the interior the "prairies" are open pastures surrounded by either timber or brush.

"Prairie" pastures usually occur in comparatively low altitudes, as on the western slopes of the hills which form the eastern wall of Russian River Valley (Pl. IV, fig. 1), where the timber is composed of oak. On Walker Mountain they ascend somewhat higher and are surrounded by brush of manzanita, deer brush, mountain mahogany, wild lilac, etc.

Around Sherwood Valley the prairies occupy the lower slopes, between the meadows and the wooded hilltops (Pl. IV, fig. 2), while in the central portion of Humboldt County they form comparatively large open clearings, several acres in extent, on knolls bordered by spruce and fir woods, as at Elk Prairie, Kneeland Prairie, and elsewhere.

Wherever these inland prairies occur the grasses and other forage plants are practically identical with those of the adjacent open ranges, of which they are simple continuations like the bays and inlets along the shores of an ocean.

THE WOODLAND OR WINTER RANGE.

The gulches and steep sides of the canyons, especially their eastern slopes, are thickly covered with trees and underbrush. Several species occur, and there appears to be little of the preponderance of one kind over another which characterizes the river bottom lands.

Trees.—The prevalent trees are: Douglas spruce (*Pseudotsuga taxifolia*); Black or Kellogg oak (*Quercus californica*), which is the largest species of oak in Mendocino County, sometimes 6 or 7 feet in diameter and with 50 feet of trunk clear of branches (Clarke); white oak (*Quercus garryana*); tan oak (*Quercus densiflora*), sometimes attaining 130 feet in height and 7 feet in diameter, one measured by the writer on the Clarke ranch having a circumference of 30 feet at 1 foot from the ground, one of its branches measuring 11 feet 9 inches in circumference at 7 feet from the trunk, and five or six limbs nearly 9 feet in circumference; Madroñe (*Arbutus menziesii*); and along the streams, pepper wood (*Umbellularia californica*). Less abundant, but by no means uncommon, are the yellow pine (*Pinus ponderosa*), chinquapin (*Castanopsis chrysophylla*), Oregon maple (*Acer macrophyllum*), and tree dogwood (*Cornus nuttallii*). The California nutmeg (*Tumion californicum*), incense cedar (*Libocedrus decurrens*), and Oregon ash (*Fraxinus oregana*) are occasionally met with, and the sugar pine (*Pinus lambertiana*) occurs on Mount Sanhedrin. The redwood (*Sequoia sempervirens*) scarcely ever grows beyond the limit of its own particular belt or isolated grove. The valley oak (*Quercus lobata*), golden oak (*Q. chrysolepis*), and other trees occur in the

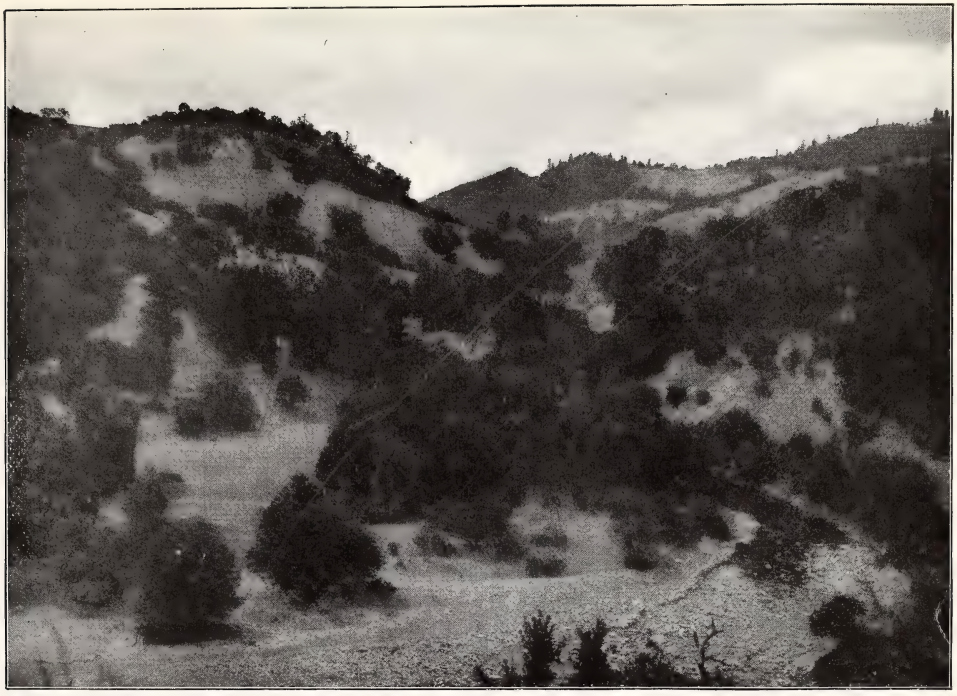


FIG. 1.—"PRAIRIE" PASTURES AT LOW ELEVATION, SHOWING THE TIMBERED CHARACTER OF THE COUNTRY. OAKS AND BUCKEYE ALONG THE RUSSIAN RIVER.

FIG. 2.—"PRAIRIE" PASTURES BELOW THE WOODLANDS, SHERWOOD VALLEY.

plateau section, but do not form a characteristic feature of the woodland.

Underbrush.—The woodland is frequently fringed with a belt of manzanita (*Arctostaphylos*). In the woods there is abundance of underbrush, in which the deer find shelter and on which they browse. It consists principally of hazel (*Corylus rostrata californica*), poison oak (*Rhus diversiloba*), cascara sagrada or pigeon berry (*Rhamnus californica*), mountain rose (*Rosa gymnocarpa*), salal (*Gaultheria shallon*), huckleberry (*Vaccinium ovatum* and *V. parvifolium*), wild blackberry (*Rubus vitifolius*), etc. In certain localities deer brush (*Ceanothus integerrimus*, *C. incanus*, and *C. velutinus*) and a species of service berry (*Amelanchier*) are found.

Herbaceous plants.—Grass species and individuals are not abundant in the shady woods, and most of those which occur have sparse foliage, affording but little feed for stock. The species most commonly met with are *Bromus lævipes*, *Melica bromoides*, *M. torreyana*, and *Trisetum canescens*. *Festuca californica*, "vanilla grass" (*Savastana macrophylla*), and *Elymus glaucus* are not uncommon.

Other perennial herbaceous plants, such as *Achlys triphylla*, *Vancouveria parviflora*, *Iris douglasiana*, *I. purdyi*, *Viola lobata*, *Aspidium munitum*, *Adenocaulon* sp., *Eriophyllum* spp., and *Brodiæa* spp. are abundant, but annual plants are comparatively rare.

Forage plants.—From off this miscellaneous assortment of plants cattle, horses, sheep, and hogs have to "rustle" a living during several months of the fall and early winter, yet they are said to keep in good condition in spite of the unpromising nature of the forage. Cattle and horses browse on poison oak, hazel, white oak, deer brush, and the few grasses they can find. Sheep freely eat, in addition to the above, the very tough and astringent leaves of the manzanita. This is shown in a striking and very characteristic manner by the neat way in which each bush is trimmed, sheep-head high, and divested of every leaf within reach.

Hogs find better picking in the woods than do other stock, and are left to run there almost the year round. They are said to live largely on the acorns of the three oaks above mentioned, on chinquapin nuts, pepper nuts (*Umbellularia californica*), madroñe, manzanita, and poison-oak berries, the bulbs and tubers of liliaceous and other plants, and on grasses and clovers. In August the manzanita berries ripen, and the hogs feed on them till the poison-oak berries, acorns, and other nuts and fruits mature. By the time these crops are exhausted the grasses and clovers are fit for food and continue till the end of June. July is the month of poorest hog feed, and it is necessary to provide corn or grain till the manzanita berries are again ripe, in August.

The acorns of the white oak are said to make the best and sweetest feed and to produce the best bacon, but the crop is very uncertain. The tan oak is the most reliable acorn producer.

Improvement of the woodland forage.—Except in portions of the redwood belt, the timber occupies land which would probably never be fit for agricultural purposes on account of either or both of the following reasons: First, the steepness of the slopes, which makes them practically inaccessible and exposes them to soil washing to a ruinous extent as soon as cleared of the protecting timber and brush; second, the poor and rocky nature of the soil. The clearing of the land would therefore be unprofitable, unless for the sake of the timber. The clearing of such lands would seriously affect the water supply of the upper ranges. This has been conclusively demonstrated near Scotia, and near Guerneville, in Sonoma County, where the clearing and keeping clear of the redwood land for pasture purposes has resulted in the drying up of many springs and small creeks which were formerly perennial. The way in which the stream beds are flooded with "waste" water from the treeless upland ranges in times of heavy rain is shown on the accompanying plate (Pl. V, fig. 1), and, by contrast, the beneficial effect of a heavy covering of timber and brush, which protects the tributary springs and creeks from evaporation, is shown in figure 2 on the same plate.

The timber produced (outside of the redwood belt) is not at present considered worth lumbering, but is used for fuel and fencing. The tan oak (*Quercus densiflora*) is highly valued for its bark, used for tanning, and an extensive industry in oak bark is carried on in the more accessible canyons near the coast. It is quite possible that the future demand for tan bark, which is becoming scarcer each year,[a] may warrant the systematic planting of the tan oak on these canyon slopes. This would result in a large increase of hog feed in the acorn season.[b]

Forage plants recommended for trial.—It is not improbable that by establishing pasture plots of shade-growing forage plants in small clearings among the timber and brush the winter feed of the wood-

[a] Some idea of the extent of the annual destruction of tan oak can be gathered from the statement that in 1899 there were shipped 1,500 cords of bark (a cord weighing 2,300 pounds) from Point Arena and 1,500 from Greenwood; 500 cords are annually peeled at the Union Lumber Company's camps near Fort Bragg, and large amounts are annually shipped from Gualala, Iversen, Navarro, Albion, Little River, Mendocino City, Caspar, Westport, Usal, and Bear Harbor, as well as from other points. We met twenty-one 4-horse wagon loads of bark en route to Bear Harbor in a morning's drive between Kenny and Thorn.

The bark from the Greenwood lumber camps is supplied "to the California Tanning Extract Company, who have a plant in conjunction with the Greenwood mill. The bark is reduced to a liquid form, and is barreled and shipped, principally to Japan. One cord of tan bark weighs 2,300 pounds; when in liquid form it is reduced down to about 550 or 600 pounds."

[b] Acorn-fed pork is, at best, considered poor in quality, being soft and oily; it brings 1½ cents per pound less than corn-fed pork; it is claimed that even though "finished off" on corn the quality of the fat remains the same. Poland-China hogs are used almost exclusively for range feeding, being much more docile than Berkshires, which become wild and unmanageable with the freedom of the range.

FIG. 1.—RUSSIAN RIVER, SHOWING THE EFFECT OF FLOODING, DUE TO HEAVY RAINFALL ON THE UNTIMBERED UPLANDS.

FIG. 2.—A PERENNIAL STREAM, HUPA VALLEY, PROTECTED FROM WASHING AND EVAPORATION BY TREES AND BRUSH.

land ranges could be increased. As these ranges are used for fall and early winter feeding, the grasses that will be of greatest benefit in such situations will be those that make the earliest winter growth.

Among the grasses which make the earliest winter growth at Berkeley the following are recommended for trial: Orchard-grass (*Dactylis glomerata*), tall oat grass (*Arrhenatherum elatius*), wood meadow grass (*Poa nemoralis*), reed fescue (*Festuca arundinacea*).

It must be borne in mind, however, that we can not expect to make first-class pastures out of timbered lands. It is impossible to successfully combine good timber cultures and good pastures, for the objects and needs of the two are diametrically opposed, and what will benefit the one may injure the other. The timber and brush are needed in order to preserve the flow of the springs. All we can hope to do in the way of improvement, therefore, is to somewhat increase the amount of grass produced in the open spaces.

THE CHAPARRAL.

Chaparral is the Spanish word for a thicket of low shrubs, and was used by the Spanish-Californians to designate the thickets of scrub-oak (*Quercus dumosa*) which are so noticeable a feature of rocky ridges in this region. It is now applied promiscuously to any low, dense brush of prickly or rigid shrubs growing in similar situations, as well as to the individual species of which the mass is composed. In these senses the words chaparral and chamisal are often used interchangeably; chamisal strictly means, however, a stretch of burned over chaparral, from the Spanish chamizo, a piece of half-burnt wood. The term is now generally restricted to the "chamise" bush (*Adenostoma fasciculatum*).

So local and strikingly characteristic are these chaparral areas that they have become landmarks, the word chamisal, sometimes corrupted into chemisal, chemise, or chimese, being adopted as a local name. Thus, we find on the map of Humboldt County a "Chemisal Creek" and "Chimese Ridge" in the vicinity of Harris, and a "Chemise Mountain," near Shelter Cove.

As before stated, the chaparral covers dry, stony ground, where the soil appears to be too scant and poor to support a generous herbaceous vegetation. It is usually composed of such shrubs as *Adenostoma fasciculatum*, *Ceanothus cuneatus*; *Quercus dumosa*, *Cercocarpus* sp. (mountain mahogany), species of *Arctostaphylos* (manzanita), *Garrya fremonti*, *Eriodictyon californicum* (Yerba santa), etc., the component species varying with the locality, and frequently one or other being so prevalent over a large area as to give it specific individuality.

The grasses usually met with in these arid, rocky spots are tufted in their habit of growth, and consequently come under the common category of "bunch grass." The species are few in number. *Melica*

californica, *M. harfordii*, *Stipa lemmoni*, *Sitanion multisetum*, *S. planifolium*, *Elymus glaucus*, species of *Poa*, *Festuca*, *Bromus carinatus*, and occasionally *Festuca ovina* being the only ones collected. *Lotus americanus* and occasionally a clump of "deer brush" (*Ceanothus integerrimus*) are the only plants met with, other than grasses, which are known to be of forage value.

The individuals of these forage plants are so few and far apart as to afford only the scantiest pickings for animals, and the brush is usually so dense that stock can penetrate it only with difficulty.

Under these circumstances a piece of chaparral is naturally considered so much waste ground, being not only unproductive or almost entirely so, but, on account of the poverty of the soil, not worth the cost of clearing.

SUBALPINE MEADOWS.

In the Trinity and Inner Coast Range mountains subalpine meadows are occasionally met with at an altitude of about 6,500 feet, which resemble to a considerable extent those of the Sierra Nevada, not only in physical and climatical features but also in phytological aspect.

I had opportunity to visit a group of such meadows on Trinity Summit, to the east of Hupa Valley, between June 21 and 23, 1899, but found that it was still too early in the season to find any but the earliest spring flowers in blossom—*Salix*, *Ribes*, *Erythronium*, *Frasera*, *Kalmia*, etc. With the exception of *Melica spectabilis* the grasses and sedges which form a dense turf on the alluvial soils in hollows just below the peaks were just commencing their new growth, and in many places were still under snow. Appearances indicated, however, that here at last we had found patches of the primitive flora still almost entirely unadulterated by admixtures of alien species. The meadows are so completely isolated from the distant valleys and lower grass-covered ridges by steep rocky chaparral ridges and stretches of spruce and tan-oak forest, covering the whole of the altitudinal distance of about 6,000 feet from the floor of Hupa Valley, that it has proved difficult for aliens to cross this natural barricade. A few specimens of sheep sorrel (*Rumex acetosella*) were found in open spots along the trail, and even on Trinity Summit, being apparently the first of the alien horde to reach those grazing grounds. It will be interesting from an ecological standpoint to watch whether other species succeed in following this irrepressible and pernicious weed.

As the growth of vegetation in these subalpine meadows is later than that at lower altitudes, on account of lower temperature and consequent persistence of snow, they are valuable adjuncts to the stock ranges, providing green pasturage for several weeks after the upland ranges at lower altitudes are dry and brown.

On the plateau, where the greatest elevation does not exceed 4,000 feet and but little snow falls in winter and none remains into the summer, the grasses mature early, and there are no late alpine meadows.

SYSTEM OF RANGE ROTATION AND MANAGEMENT.

In California the season of activity in plant growth commences with the early autumn rains (September and October), while the heat rays still have power to warm the soil below the surface. It is then that the seeds of annual plants, dormant since the time of ripening in early summer, commence to germinate and the seedlings to establish themselves in the loosening soil.

Though they germinate so early in the season these annuals do not make much upward growth until the advent of the warm spring days during February or early March, after which their progress to maturity is usually rapid. By April-May or May-June, according to the season, they have attained their maximum growth and begin to ripen or are at least flowering.

The flowering season is short, and with the arrival of the hot, dry, north winds in June or July the open hillsides rapidly assume that brown and barren aspect so characteristic of a California summer.

During the fall and early winter months, when the "bands" of cattle and sheep have been reduced by summer sales of fat stock, it is customary, on ranges under the best management, to confine the stock to the woodland or winter range. This method gives the seedling annual grasses and clovers, which furnish most of the forage on the summer range, a chance to get well anchored in the soil and fairly established; otherwise, on account of their shallow rooting, a large proportion would be destroyed by trampling or pulling.

As soon as feed is sufficiently plentiful the "bands" are permitted to return to the summer range. With the advent of the dry season the animals are usually ready for market and stockmen begin to thin out their flocks and herds. A general exodus soon commences, the marketable animals being driven to Ukiah or Eureka for shipment to San Francisco.

With this exodus of sheep and cattle summer travel over the stage road from Ukiah to Eureka becomes more than ever unpleasant. The roadsides which a short time previous were carpeted with grasses and wild flowers are quickly stripped of every blade of green, and the roads, hitherto fairly good, become thick with dust, which is thrown up in clouds by the numerous droves of animals passing each day.

The reserve "bands," now much reduced in size, continue to find subsistence, and even keep fat for some time, on the ripening heads of soft chess and other forage plants which are now dried into a standing crop of short hay. This cured hay is considered highly nutritious until it has been washed by the early rains, when it seems to lose its palatableness.

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In the Trinity and Inner Coast Range mountains, as well as in the Sierra Nevada, it is customary to drive the stock up the mountains to the subalpine meadows for summer pasture. For several years the Hupa Indians have followed this practice on Trinity Summit, the meadows which occur at about 6,500 to 7,000 feet altitude being a favorite range for the cattle of the reservation.

CARRYING CAPACITY.

Present capacity.—It is difficult to obtain exact data as to the present carrying capacity of the ranges, stockmen being loath to give figures for obvious reasons. The Blue Rock Range, of 2,500 acres, is said to carry 1,200 head of sheep and 100 head of horned stock, or an equivalent of an acre and a half to a sheep and 7 acres to each head of cattle. This is the same ratio for sheep as is reported for the prairies around Sherwood Valley. On the ranges near Bells Springs the maximum capacity is given as little more than an acre to one head of sheep, and 5, 6, or sometimes even 10 or 12 acres to one head of cattle. It is said that on the poorest ranges, which have become worn-out by overstocking, it takes 20 acres to support one head of cattle.

The ranges on Walker Mountain and Sherwood Mountain seem to be in better condition than those north of Cummings. Danthonia and soft brome grass are much more abundant and the maximum carrying capacity is higher (at present), the ratio being reported as only 4 or even 3 acres to one head of cattle. The latter figures may, however, apply only to open range or may include winter pasturage in the meadows instead of on woodland "browse." Such heavy stocking can not long be maintained, however. Mr. Blair, on Sherwood Mountain, has 200 acres of range and carries 60 to 80 head of hogs, 40 to 50 head of cattle, and a few horses.[a]

On the ranges which were found to be in the best condition it was learned that not less than 8 acres was allowed for each head of cattle and 1½ acres for each sheep.

Colonel Harding's range of some 13,000 acres is said to carry about 400 cattle, 100 horses, and 5,000 sheep, or a total equivalent of some 1,600 head of cattle, about 1 to 8 acres.

These ratios are supposed to include both open and woodland or brush range. It is said that there are usually about 2 acres of the latter to every 1 acre of clear land, but the proportion varies somewhat with the locality. Open range alone is said to be capable of carrying 1 head of cattle to 4 or 5 acres and 1 head of sheep to 1 acre during the season.

Former capacity.—The first white settlers in the valleys north of Walker Mountain appear to have located in 1852 or 1853, and they

[a] It is possible that my informant was in error as regards these figures. I much doubt whether any range in the region is as heavily stocked as this statement would indicate.

either brought bands of cattle with them or drove them in a year or two later, and for several years the region was a great unfenced cattle range. Humboldt County was first settled in the vicinity of Humboldt Bay in 1849 or 1850. A cattle ranch was maintained in Clear Lake Valley prior to 1849 by Andrew Kelsey and Charles Stone, who were murdered by Indians in December, 1849.

According to Carl Purdy,[a] "for years Mendocino County was a cattle county, with all the wild lawlessness which pertains to that industry and conflicting squatters' rights. As the wild animals were killed out the high price of wool stimulated sheep growing; until 1875 the mountainous country was almost entirely devoted to that branch of grazing. Then the mountain land was surveyed and landowners obtained titles, lands were fenced, and the second stage of grazing reached. The large profits in sheep raised the price of grazing lands to too high a figure, and graziers were tempted to overreach themselves by the purchase of surrounding lands." Then came a fall in the price of wool, and many rangers replaced their sheep with cattle; others, "overloaded with debts accrued by land purchases, went into bankruptcy." At present the sheep and cattle industries on the ranges are of about equal importance.

It is even more difficult to obtain information as to the actual condition and vegetation of the ranges in the first years of occupation by white people than about the present carrying capacity. There are various indications, however, pointing to a much more highly productive condition in those early days than has been realized for many years.

The fact that at the present time the three most abundant grasses are adventive species of foreign origin favors this view. There is evidence that they have become naturalized within comparatively recent years. Small barley grass and soft chess are not recorded as occurring in the State at the time of the State geological survey in the early sixties, and Dr. Bolander, who at that time was making a special study of the grasses of California, does not appear to have collected squirrel-tail in either Mendocino or Humboldt when he visited these counties in 1864 and again in 1865. It is evident, therefore, that these grasses, now so abundant, are not only naturalized aliens, but also that they must have replaced other and equally abundant species, since it is inconceivable that in such a climate fertile soil could long remain other than densely clothed with some kind of vegetation. Old-timers are unanimously agreed, moreover, that the feed on the ranges has changed materially since they first settled in the country. Mr. Bell, of Bells Springs, says that the feed on his ranges has changed several times during the twenty-seven years he has lived there, "new" (adventitious) species coming in, becoming predominant, and in their turn giving place to others.

[a] Ukiah Dispatch-Democrat.

Colonel Harding states that small barley grass (locally called foxtail) was brought in by sheep, being observed first along their tracks.

The questions, then, arise, what were the components of the primitive vegetation which occupied the place of the present alien flora; how did it compare with the latter as regards forage value, and what new species came in, became prevalent, and then gave place to others.

The earlier floras appear to have been composed of plants more generally acceptable to stock than the weedy species now prevailing, otherwise they would scarcely have given such complete place to alien species. In other words, if they had not been highly palatable to stock they would not have been "eaten out," and if the adventive species had been equally palatable they could scarcely have acquired a foothold under the system of heavy stocking which has prevailed.

Few residents in this region are sufficiently familiar with plants to define the actual changes in the flora which take place over a period of years. Some, however, have noticed the change in composition of the range feed. Mr. Bell, Mr. Joseph H. Clarke, and others state that danthonia and other "bunch grasses," wild oats, alfilerilla, clovers, wild-pea vines (*Lathyrus* sp.), and wild sunflower (*Wyethia* sp.) were formerly the most abundant plants on the ranges. All these, they state, have been materially reduced in quantity or have disappeared altogether, and in their places squirrel tail, small barley grass, and soft chess have become established since they settled in the county. These statements are in part confirmed by Menefee, who, writing in 1873, says of this section of Mendocino County:

> The soil is * * * covered with a rich growth of clover, wild oats, bunch grass, and rosin weed or wild sunflower.

All of the above-named plants are now relatively scarce.

Wild oats and alfilerilla were not, however, the primitive forage plants, for they also are aliens, natives of the Mediterranean region, their introduction into California probably dating from the Spanish occupation. Being adventive, they too must have replaced other plants which were probably native in the sense of not having been introduced through the agency of man or his domestic animals, since we have no records of immigration earlier than that of the Mission Fathers.

On account of their wide distribution in the State, and their abundance and prevalence in the fifties, many persons have refused to believe that wild oats and alfilerilla could be other than native to the soil; even Bolander, writing in the early sixties, was inclined to believe that they must be native alike in southern Europe and California. To anyone who has watched the rapid spread of alien weeds in the rich soil and favorable climate of this State, and has observed one alien gradually give place to others, the century and a quarter which has elapsed since the Spanish occupation will appear none too short to witness the occupation of the whole State by such prolific plants as

wild oats and alfilerilla, and the later disappearance of one or both of them by overstocking. This matter will be more fully discussed after the causes of range deterioration have been considered.

Col. Redick McKee, United States Indian agent, with a military party, passed over the plateau region from Santa Rosa to Humboldt Bay in the fall of 1851. Mr. George Gibbs, who kept the official diary of the party, mentions[a] that wild oats were very abundant on the slopes of the lower foothills from Santa Rosa northward. Before reaching Feliz Valley, the most northerly Spanish ranch in the Russian River Valley, he notes: "The hills passed to-day were covered with bunch grass, the wild oats having disappeared." Wild oats were again observed on what is now known as Walker Mountain, but were not noted from any place to the northward, though bunch grasses are frequently mentioned. There is no mention of alfilerilla. Colonel McKee's party seems to have been only the second white party to make the overland trip.

What then were the prevalent plant species before the advent of wild oats and alfilerilla? Though no written record appears to exist, this question can be answered in a fairly satisfactory manner by inference. It is unreasonable to suppose that in the comparatively short time (some fifty years only) which has elapsed since these hills were first ranged by white men any of the then prevalent plants could have become extinct. We must therefore look for them among the species still to be found in protected places on the ranges. In fenced-off areas surrounding some of the springs on the Bell's Springs Range and a few other places, are still to be found luxuriant growths of native clovers, grasses, and other plants which have been somewhat protected from their natural enemies, the range stock. Of course weedy grasses, with alfilerilla and wild oats, have found their way there also; but the native species have been able to hold their own to a greater extent than elsewhere. The vegetation of such places gives us a clew to the former condition of things. Here are found the native annual clovers, *Trifolium cyathiferum*, *T. bifidum decipiens*, *T. tridentatum*, *T. variegatum* var., *T. microcephalum*, and *T. furcatum virescens*, making a luxuriant growth, sometimes almost knee-deep. Sheep fescue (*Festuca ovina*), danthonia (*Danthonia californica*), *Sitanion multisetum*, *S. planifolium*, *S. villosum*, and *Elymus angustifolius*, all promiscuously known as "bunch grasses," together with "wild pea-vines" (species of *Lathyrus*) and "wild sunflower" (species of *Wyethia*), are also plentiful. In dry, rocky places California melic grass (*Melica californica*), Lemmon's bunch grass (*Stipa lemmoni*), and one or two species of meadow grass (*Poa*, allied to *P. fendleriana*) are frequently found. These are also called "bunch-grasses."

[a] Gibbs, George: "Journal of the expedition of Col. Redick McKee, United States Indian agent, through northwestern California, performed in the summer and fall of 1851." Published in Dr. Henry Schoolcraft's Archives of Knowledge, ———: 99–177. Philadelphia, 1860.

It thus appears that these same clovers and other annual plants and the same perennial "bunch-grasses," which are now but sparingly found, were in former times the common plants of the open range, and that the species now most abundant, including alfilerilla and also wild oats, were unknown here before the Spanish occupation of California.

The following conclusions, therefore, were accepted:

1. The primitive forage plants were the "bunch-grasses" (Danthonias, Stipas, Melicas, Poas, and perennial Festucas), with annual and perennial clovers, wild pea vines and wild sunflowers; these were much more abundant in former times than now, and on account of their palatableness they largely disappeared with overstocking.

2. With the advent of white settlers and their domestic animals, wild oats and alfilerilla (*Erodium cicutarium*) took possession of the country; these increased in relative abundance as the native forage plants became scarce; as the latter diminished in quantity cattle took to eating the former until they in like manner succumbed, while other plants took their places.

3. Small barley grass, squirrel tail, and soft chess were among the next weedy introductions; the two former, when in a maturing condition being disliked by cattle, have had a chance to spread and cover the ranges, but cattle having acquired a taste for soft chess, it is being kept in check, if not diminishing, on closely grazed ranges.

4. A third immigration is now taking place, in which musky alfilerilla (*Erodium moschatum*), broncho grass (*Bromus maximus gussoni*), barley grass (*Hordeum murinum*, locally called fox-tail), tacalote (*Centaurea melitensis*), hawkbit (*Hypochœris glabra*), bur-clover (*Medicago denticulata*), and other weeds are establishing themselves along the roadsides and around ranch houses. Of these, the bur-clover, and the musky alfilerilla, have some forage value. Barley grass is eaten green in the spring before heading out, but afterwards becomes one of the most objectionable weeds for a stock range. The other aliens are destined to cause irreparable injury to the ranges unless kept in check and prevented from becoming firmly established.

RANGE DETERIORATION.

Primary cause.—Range deterioration is traceable to the desire to make as much off the land as possible, coupled with two mistaken ideas: (1) That a range can continue to carry the maximum number of stock without deterioration year after year without any rest; (2) that in order to get the most out of a range in a given period of time it must be stocked to its maximum carrying capacity.

By maximum carrying capacity is meant the highest possible number of stock that the range will turn off in good condition at selling time, without taking into account the condition of the range itself; in other words, it has reference purely to the present crop of stock,

without reference to the range or to future production. The optimum carrying capacity, on the other hand, means the highest number that can possibly be carried without injury to the range, providing for the production of future crops, and eventually, therefore, bringing the best results both to range owner and occupier.

On ranges which are not stocked beyond the optimum the animals are not likely to depasture any one spot, and a sufficient number of plants of alfilerilla, native clovers, danthonia, and other bunch grasses will thus be left to ripen seed for another season's growth. Having more space over which to roam, the stock will spend less time in one place, doing less injury to the bunch grasses by their trampling. The number of stock which make the difference between the maximum and optimum carrying capacity costs more to the range owner in permanent and irreparable damage to his property than they can bring back in cash value. While every head of stock put upon the range, until the optimum is reached, is equivalent to so much additional profit, every head carried beyond the optimum not only ceases to be a source of profit, in that it limits the supply of nutritious plants both for itself and the rest of the herd, but also causes deterioration to the range. The amount of deterioration can not be measured by the actual amount of feed eaten, but increases with geometrical progression to an astonishing degree, determined by the number of useful plants left to ripen seed for the next year's crop. Looked at from this standpoint, it is evident that when an annual range begins to deteriorate the deterioration will continue at a rapid rate until checked by a change of method in management.

Stockmen all admit that overstocking is a bad practice, and condemn it; but each man has his own conception of what overstocking is, the number of acres required per head ranging all the way from 3 to 20 acres, varying somewhat, to be sure, according to the condition and situation of the range. Doubtless the point where the overstocking commences is determined, with most stockmen, by the condition of the stock, without regard to that of the range; few would realize that by running all the stock the range will carry they are actually overstocking—that is to say, seriously depleting the range and reducing the number of head which can be carried in future years.

Unlike arable land, which is cultivated and resown artificially year after year and on which the crops can therefore be cropped close without injury, a stock range has to seed itself naturally, and on account of the high mortality percentage among seeds under ordinary conditions it must be allowed to seed itself heavily or else it will deteriorate.

Excessive land valuations.—In discussing values the distinction between an annual and perennial range must be borne in mind. The annual range is much more subject to change than the perennial range; therefore the difference between maximum and optimum

capacity is very much greater in the case of the former than of the latter. The value of a range, moreover, depends not alone on the number of head it will carry, but also, and primarily, upon the nature and quality of the forage. If the prevailing forage plants are annuals, or even perennial bunch-grasses, the maximum carrying capacity, for a few years at least, may be as high as a range producing turf-forming or creeping-rooted grasses, but its optimum will be much lower.

How overstocking effects deterioration.—Two factors are at work on range deterioration. One is the destruction of the choicest forage plants by selection; the other the introduction of uneatable weeds which, multiplying rapidly, crowd out the often less vigorous, useful species, and fill the spaces left vacant.

So long as there is a choice left to them, stock naturally wander over a range, picking out from among other plants the specially palatable species. Thus, by close cropping, the favorite forage plants may be almost entirely prevented from seeding. On an "annual" range most of the plants, being shallow-rooted annuals, are easily pulled out and destroyed. As they depend entirely on the production of seed for the propagation of their kind, it is clear that in this way their number is rapidly diminished. A few always escape, on account of their situation in secluded places, or because of their depauperate size, or from other causes, but these are too few in number or too poor in seed production to maintain the productiveness of the range.

On a virgin range there is not only an abundance of plants sufficient to feed all the stock and to scatter seed as well, but also a large quantity of ungerminated seed lying dormant in the soil. On this account it is clear that such a range may be stocked to its maximum capacity, for a short time, without injury. After a year or two, or perhaps a still shorter time, the granary of surplus seed is exhausted and heavy stocking prevents the formation of more than a small quantity of new seed. Then deterioration commences. Every plant eaten means not only the loss of one individual but also the destruction of so much reproductive power. Formerly there were plants enough not only for forage but also for seeding; now, every one eaten represents so much seeding capacity destroyed. And herein lies the difference in value (now represented by many dollars) between the annual and the perennial range. As an annual range depends on the production of seed for its preservation, close feeding means the destruction of the next generation as well as the present. A perennial range, on the other hand, does not depend upon seed for its preservation and often not for its reproduction; for the individual plants live on from year to year and the best of them propagate themselves from their running underground stems. Such plants can be pastured comparatively close, not only without injury but with absolute benefit, for close grazing induces them to throw out more roots and form a denser turf.

The selection by stock of the choicest of the annual plants hastens

deterioration in another way. The reduction in the number of plants leaves so much more nutriment and space available for the growth of weeds and other less valuable species. Weeds invariably follow the introduction of stock into a country. By range weeds we mean any plants of thrifty, vigorous habit, which are distasteful to stock. Just as certainly as the selection by cattle of the choicest plants makes it difficult for them to maintain a foothold, so surely does the same process of selection allow the weeds every opportunity to increase, by maturing and scattering seed without let or hindrance.

These weeds are largely alien species, introduced chiefly by accident, with the advent of the white man, or along with the domestic plants and animals introduced by him at a later date. They are often plants which have become hardened to much more adverse conditions of soil and climate than they find in California, and therefore grow with greater luxuriance and spread with greater rapidity than species which have, by long continuance under uniformly favorable conditions, shown a tendency to "run out" or to deteriorate. The struggle for existence seems to be as keen among plants as among human beings, and if one species or race is killed out by its animal or other enemies, another race, less liable to attack by the same kind of enemy, steps in to fill the space. Under these conditions it is evident that on an overstocked annual range those species which are especially palatable to stock will have little chance to propagate their kind.

Wild oats and alfilerilla.—If the destruction of the most palatable forage plants by selection is constantly going on, how could such palatable species as wild oats and alfilerilla ever have become so abundantly naturalized as to be the prevailing plants on the ranges in the relatively short time since the Spanish occupation of California? And if they had at one time been able to establish themselves as aliens would not the same factor which enabled them to establish themselves prevent their being killed out by pasturing at a later date? Is it not more probable that they are indigenous species, which have suffered numerical diminution in the same way as have the wild clovers? Such are the questions asked in this connection. We are not at present prepared to answer them decisively, but to anyone who has watched the spread of introduced weeds in California, especially those from the Mediterranean region, the exotic origin and rapid increase of wild oats and alfilerilla will not appear improbable, even in the face of general range deterioration. Usually European weeds find themselves quite at home on the soil of this State, new to them, and comparatively unimpoverished. Annual species, especially, spread with great rapidity. If the wild oats and alfilerilla were introduced at the time of the Spanish occupation, when cattle were comparatively few in the land, they would have abundant opportunity to "take" the country in spite of being relished by stock. Later, however, as cattle multiplied, and sheep were introduced, forage became

relatively less abundant, and at the same time weedy species, such as small fox-tail and squirrel-tail, less liked by cattle, came in, gradually monopolizing the ground left vacant by the destruction of the wild oats and alfilerilla.

Exactly the same process of introduction and eradication is taking place at the present time under our own eyes. Soft chess has, within recent years, taken possession of the hills in some parts of the State, much to the disgust of stockmen. Sooner or later the cattle have taken such a fancy to the new forage, either from necessity or choice, that it, in turn, has been almost eaten out, enough being left to show that it was once there, and other species not yet liked by cattle are taking its place.

So this process of elimination or natural selection goes on. Species which are liked by stock, but which are unable to retain their hold on the soil when grazed or trampled, disappear or become scarce, and other species come in and take their place. These, in turn, must pass away if unfitted to maintain the struggle for existence. Only the fittest survive—the fittest from the standpoint of the plant—the least fit (the weedy, useless species) from the standpoint of the rancher.

Bunch grasses.—The fact has already been alluded to that the so-called "bunch grasses" are not as well adapted for grazing as are running and turf-forming species. On account of their tuft-forming nature the former are more easily pulled out than are species which spread by means of underground rootstocks.

Sheep versus cattle.—Cattlemen think that the great depreciation in carrying capacity is due to sheep, claiming that sheep do far more injury to a range than do cattle. This is only partially true, however, and while it may be true that a range overstocked with sheep will suffer more on account of their close biting than one overstocked with cattle, which do not graze so closely, it is equally true that a sheep range carrying only the optimum number can be kept in better condition than a cattle range which carries the maximum number. Sheep do no more damage than cattle if properly handled and not crowded, and they can be kept without injury to the range; in fact, it was claimed by intelligent stockmen, accustomed to handle both sheep and cattle, that certain sheep ranges in Mendocino County were at the time of this investigation in better condition under sheep after three years of comparative drought than they were thirty years ago.

It is an indisputable fact that some men have made a financial success of sheep raising on the open range, and that at the same time their ranges are in as good condition, and in some cases better, than adjoining cattle ranges.

It is not improbable, however, that sheep do more damage than cattle to perennial "bunch-grasses."

Summary.—The cause of range deterioration, therefore, is overstocking, and it is the animals themselves that do the damage. Fur-

ther, the point at which overstocking commences has not been decisively defined and varies with the individual range. What, then, can the stockman or range owner do to improve his condition? He may well say that the range is run for the sake of the stock that can be raised on it and not for the sake of preserving the feed, and that though stock may be the cause of range deterioration they can not be eliminated from the problem.

The task is only just begun, however, and the problem can not be solved immediately. In the following pages some suggestions are offered which it is hoped will prove steps toward the desired end.

RANGE PRESERVATION.

It is important to reiterate that if range renewal or improvement is to be accomplished, the practice of carrying the maximum number of stock on the range, or, in other words, of overstocking, must be abandoned. It is believed that it is possible to permanently raise the optimum carrying capacity, but it is impossible to do so while heavy stocking is practiced.

Success on one range, as compared with failure on an adjoining one, is not due to any difference in location or other range conditions, nor to any differences in the grasses or other plants composing the pasture; the natural conditions generally are, or have been, identical with those of adjacent and less-productive ranges. The secret lies in good management, and good management primarily consists in carrying the optimum number of stock and allowing plenty of grass to go to seed—to go to waste, as the majority of stockmen would call it.

Mr. J. H. Clarke and Colonel Harding, both successful stock ranchers on a large scale, are agreed in declaring that over thirty years of experience proves that this surplus grass, instead of being wasted, is equivalent to so much capital invested in the range, and is the cause of the prosperity of the few as compared with the failure or poverty of the many. Such men do not stock nearly up to the maximum. Owning their own ranges, and therefore not having to pay exorbitant interest on the capital invested, they are content with the profits obtainable from the optimum number of stock. As a result of this, they not only maintain a uniform carrying capacity without deterioration, but gain in other ways. Their wool is always cleaner and commands a half a cent a pound more than that of their neighbors, and both their mutton sheep and their lambs command a higher price. "We aim," writes Mr. Clarke, "to keep no more stock than the range will easily support. Better a superabundance of feed than a scarcity." The amount of grass to be left to seed and the optimum carrying capacity can be determined only by actual experience. Both Colonel Harding and Mr. Clarke find, however, that about 8 acres to a head of horned stock and $1\frac{1}{2}$ acres to a sheep are all that their ranges can carry without injury.

Formation of a seed bed.—The advantage gained by allowing a great deal of grass to go to seed is not only the amount of seed scattered, but also the formation of a seed bed of decaying leaves and stems, which encourages germination and protects the young seedlings.

Preserve the timber and brush.—Next in importance to preservation of the forage plants is the conservation of moisture in the soil and the preservation of the water supply. The ranges which we are discussing lie along the headwaters of the main streams of the coast, and the preservation of a perennial flow of water in these streams is of as much importance to places many miles away as to the ranges themselves.

In their desire to increase the carrying capacity of the range many men commence first to clear the land of all timber and brush with a view to producing just so many more acres of pasture. Unfortunately, however, by clearing away all the brush and timber from the gulches and springs the moisture content of the soil is diminished, the available drinking water for stock is rendered less accessible, and there is probability of greater financial loss than profit from the labor expended. In the Redwood belt it is noticeable that where both timber and brush have been cleared away springs and small streams have been dried up, although the conditions for the preservation of perennial springs and streams are more favorable there than on the upland ranges. Not only is the summer water supply diminished by removing timber and brush from the headwaters of the streams, but the soil on the steep slopes washes away with much greater rapidity, owing to lack of protection from fiercely beating rains, thus increasing the depth and steepness of the canyons, which in turn facilitates the washing away of soil from the upland slopes. In Europe and elsewhere much valuable land has been ruined in this manner.

Maximum versus optimum stocking.—While it is impossible with our present imperfect knowledge of the facts of the case to determine the exact difference between the maximum and the optimum of range capacity in any case, it seems certain that a very slight reduction in size of the "band" of stock to a point below the maximum would soon make an appreciable improvement in the carrying capacity of the range and would be a step toward its renewal.

The practical stockman will naturally inquire whether the resulting gain would be worth the sacrifice of even that number of head of stock, representing just so much hard cash deducted from the annual profits of the range. If it would not, he will not be likely to take any further notice of the suggestion. In order to get as accurate an answer to this question as is possible without direct experiment, let us take a hypothetical case by way of illustration.

We will suppose that we are dealing with a range of 1,800 acres, stocked to its maximum carrying capacity, and that this maximum is

5 acres to one head of cattle, and its optimum 8 acres to one head. This range would thus be carrying 360 head of stock; reduced to the optimum, the herd would number 225, a reduction of 135 head, or 37½ per cent.

Though such a reduction seems heavy, it must be borne in mind that some of these annual ranges have naturally suffered a reduction by overstocking till it takes 10, 12, or even 20 acres to support an animal, which means that the herd has been reduced from sheer lack of feed from 360 to 180, 150 or even 90 animals to an area of 1,800 acres. This does not take into consideration the possibility of still further reduction of carrying capacity to 20 acres to a head, which is said to be sometimes the case, but which is perhaps due to very exceptional circumstances.

The question to be considered is whether it is more profitable (1) to continue stocking up to the maximum capacity of the range, with the almost certain result of a forced reduction of the herd by 50, 60, or possibly 75 per cent in a comparatively short time from lack of feed, or (2) to voluntarily reduce the herd to the optimum capacity of the range, equivalent to, say 37½ per cent reduction, with the result that this capacity can be maintained indefinitely, that the stock will be in better condition all the time, and will command higher prices than those from depreciated ranges.

A few figures may help to make the case clearer. We have no data as to the actual number of years that one of these annual ranges can continue to carry the maximum number of head without deterioration, nor do we know how long it has taken them to run down to their present poor condition. It does not seem probable, however, that it would take more than fifteen years of carrying all the stock a range can possibly feed to reduce its capacity from 5 acres to 10 or 12 acres per head.

If, for argument's sake, we take the arbitrary figures of fifteen years, and assume, moreover, that the range of 1,800 acres has been used to fatten yearlings, all of which were sold off the succeeding year and new stock purchased, the aggregate number of cattle carried in the fifteen years under the plan of stocking up to the maximum would be 3,930, and at the end of the period the carrying capacity would have been reduced from 360 head to 150 head. Supposing that this ratio of 150 head could be maintained for the next thirty years, we should have an aggregate number of 8,430 head of yearlings raised in the forty-five years.

If, however, we reduce the herd to the optimum at the outset, we should find the aggregate number raised would be 3,375 head, in fifteen years 555 head less than by the old method; but at the end of the fifteen years the herd numbers 225 instead of 150, and this number can be maintained indefinitely; in ten years more we find that the aggregate has risen to 5,625, as against only 5,430 by the maximum method, an increase of 195 head, and by the end of forty-five years

the aggregate is 10,125 head, an increase of 1,695, which at a valuation of $15 per head would be worth $25,425.

Unfortunately these figures are not decisive, owing to lack of data as to the actual length of time it takes an overstocked range to deteriorate from 5 acres per head to 10 or 12 acres per head. It is hoped, however, that they will be of some service to stockmen in calling to their attention a method by which they may calculate for themselves, with the data of their own ranges before them, whether it will pay to reduce their flocks and herds to the optimum carrying capacity of their ranges.

But whether the hypothetical figures are based on correct premises or not, the accuracy of the statement can not be denied that there are men to-day who are profitably running cattle and sheep ranges on the basis of the optimum carrying capacity of the range, while their neighbors on the maximum method find it hard to make a comfortable living, and many of them have mortgaged their ranges up to the limit or have lost them through foreclosure.

RANGE RENEWAL.

The stockman whose range capacity is already as low as 10 or 12 acres per head is less interested in the difference between maximum and optimum than in the problem of range renewal, i. e., the possibility of restoring his range to a capacity of 8 or possibly 5 acres.

Though something can be done toward range renewal, probably without actually diminishing the income over a period of years, by ascertaining the optimum carrying capacity and reducing the band correspondingly, it may be found necessary, where a range is worn out, to resort to other measures to restore it to a profitable condition. In such cases a complete rest of one or even two years will undoubtedly prove highly beneficial, giving the native forage plants a chance to attain a luxuriant growth, and to produce and scatter the largest amount of seed possible, in order to reestablish themselves. Where a mortgage has been foreclosed, such a period of rest can often be accomplished while waiting for a purchaser or tenant. But to make it effective, the fences must be maintained in good condition, in order to keep out stray stock, especially horses. Some of the ranges in Mendocino County, which were lying idle during the summer of 1899 on account of foreclosure proceedings, instead of improving by the enforced idleness, suffered from the depredations of bands of stock which had either strayed there or were purposely pastured free of charge, en route to market, having gained access through gaps in the dilapidated fences. If a range is worth anything at all, it is surely worth keeping well fenced, and the cost of maintaining good fences should be as a mere trifle compared with the increment of value gained by a period of complete rest.

In many cases it may not be necessary to give the whole range a

rest at one and the same time. Mr. Bentley, in his report[a] on the forage plants of central Texas, tells us that in that region, where overstocking has resulted in serious range deterioration, "some of the leading stockmen are now dividing up their holdings into several pastures, one being held exclusively for winter use, another for spring, another for midsummer or autumn. This practice will, in the case of the winter pasture, enable the early grasses to ripen and shed their seeds." Such a course may not prove as practicable or as beneficial, however, on the annual ranges of northwestern California, where the majority of the forage plants start growth together and mature at almost the same time, as it may be in central Texas, where, as Mr. Bentley says, "there is a great variety of native forage plants and grasses, comprising species that appear in succession from February to November." The practice may prove more adaptable, however, to the ranges of the coast-bluff belt.

Instead of resting the whole range at once and thereby, perhaps, missing a season of exceptionally good prices or of more than the usual quantity of feed, a portion of the range, say one-seventh part, could be fenced off and rested each year, the herd being weeded out at the same time, so that it will not exceed the optimum for the remainder of the range. At the end of seven years the rotation should be repeated, and there is little doubt that by some such method the carrying capacity could be gradually raised.

Where injurious weeds, such as tacalote (*Centaurea melitensis*) abound it will be found worth while to mow them off before they head out.

There are two questions to be answered in deciding the policy of range holding and stocking. First, is it good policy to allow the cash value of the range to deteriorate, if there is a way to prevent it? It is a true proverb which says "you can not both eat your cake and have it;" and overstocking is, as we have endeavored to prove, equivalent to living upon both interest and capital, a sure way to diminish both.

The stockman who owns his range will see the force of this point more quickly, and will be more willing to act accordingly, as far as he is able, than the renter. He will realize that as long as he can make a living off his range he can not do better than invest any surplus in improving the condition of both range and herd by weeding out and keeping the number down to the optimum. The stockman who rents his range, however, acts on a different principle. His sole object is to make the most out of the range and to invest his surplus in more stock or in other lines. Naturally he does not care anything about maintaining the value of the real estate, as it does not belong to him, and as a result the rented range usually suffers most severely.

[a] Bentley, H. L.: A Report upon the Grasses and Forage Plants of Central Texas; U. S. Dept. Agric., Div. Agros., Bull. 10: p. 10, 1898.

This evil can be remedied to a great extent by one or other of two methods: (1) A system of long-term leases, under which it is to the tenant's interest not to materially reduce the carrying capacity, at least during the term of his occupation; and (2) a clause in the lease limiting the number of head to be carried on the range. In the latter case it will obviously be necessary to exercise great care not to sign for more than the optimum.

The second point to be considered is one which affects both the owner and the holder of a long-term lease. It is whether it is ever wise, from the point of view of personal economy, to stock beyond the optimum carrying capacity. In view of the fact already pointed out, that when once commenced the deterioration of an annual range proceeds with great rapidity, it would be poor policy to continue to carry 1 head to 5 acres, or 360 head on a 1,800-acre range, with the certainty of its reduction to perhaps 150 head in fifteen years' time, if by reducing the herd at the start to 1 head to 8 acres, or a total of 225 head, the same total profits could be obtained in a total period of twenty years and the size of the herd and the range capacity be undiminished at the end of that time.

RANGE IMPROVEMENT.

By range improvement we mean not only its restoration to its former carrying capacity, but also an improvement of the character of the range and of the quality of the feed. This is effected by the introduction of other kinds or races of forage plants.

In order to understand fully the problem of range improvement, thereby guarding against wasted effort in directions which offer little chance for success, it is necessary to appreciate the conditions which determine the character of the forage plants on a particular range.

What causes the difference between the annual and the perennial ranges of northwestern California? The perennial ranges (if we exclude alpine meadows) are found only along the coast bluffs, where the climate is relatively cool and moist in summer, owing to proximity to the ocean and the prevalence of summer fogs. It must not be supposed from this that these maritime perennial ranges keep green throughout the summer. They do, however, keep green some weeks later than the interior ranges, which feature, together with the fact that they do not deteriorate as rapidly as the annual ranges, makes them more valuable than the latter.

The annual ranges, on the other hand, are found in the interior, beyond the reach of the sea fogs. The open ridges are exposed to the full force of the scorching north winds and great sun heat during a period of sometimes eight to ten or even more weeks of absolute freedom from rain.

It is evident that the essential characteristics of good forage grasses best adapted to the dry, interior ranges are: (1) Adaptability to the peculiar climatic conditions; (2) tenacious hold on the soil, i. e.,

capability of withstanding trampling and grazing; (3) persistence for more than one year; (4) propagation from the roots rather than from seed.

The species which appear to best meet these requirements, and which are therefore recommended for trial on the annual ranges, are: Buffalo grass, blue grama, white clover, red fescue, sheep's fescue, hard fescue, bur clover, California lotus, and Australian ray grass.

All these species have proved suited to the climate and conditions at Berkeley, but whether or not they will be found thoroughly adapted to the climate of Mendocino and Humboldt counties can be determined only by experimental culture on the ranges themselves.

If possible, they should be planted out at the time of the first fall rains. They should in any case be carefully fenced from stock until thoroughly established. It will be advisable to sow at the same time seed of some annual species, such as soft chess, which will act as a nurse crop while the perennial species are establishing themselves.

If it is intended to sow seed in quantity, it will be wise to have it carefully examined at the time of the purchase, and only to purchase clean seed, free from seeds of injurious weeds. Some stockmen have injured their ranges almost as much as they have benefited them by the introduction of injurious weeds along with the seed of valuable forage plants.

The writer does not presume to prescribe an absolute and infallible remedy for worn-out ranges. Each range has, to some extent, its own individual peculiarities, and the man who has lived several years on the land, through divers seasonal variations, should be the one best fitted to decide how to treat that land. In matters of range renewal and improvement it is the practical and well-informed stockman himself who will have to bring the ranges back to their full carrying capacity. However, such a man is always looking for suggestions, and it is with the view of bringing them directly to his notice that these pages have been written; they are simply suggestions, and their adaptability to divers conditions must be decided by the stockman.

THE COAST-BLUFF BELT.

CLIMATOLOGY.

The climate of the belt lying immediately along the coast is more equable than that of the higher interior region; proximity to the ocean renders the winter climate milder, and snow is almost unknown, except, perhaps, on the high peaks of Cape Mendocino. In summer the prevailing northwest winds are cold and the heavy sea fogs prevent any excess of sun heat, so that even in July and August warm underclothes and an overcoat are acceptable adjuncts to a stage ride. The summer precipitation is greater here than in the interior.

This moisture of the atmosphere makes it difficult to harvest a good

quality of grain hay, and oat hay, of which a considerable quantity is raised, is usually dark in color. The greater moisture also favors the development of rust, which does much damage to grain hays.

The stock ranges along the coast are limited to the narrow mesa or bench between the cliffs and the first mountain ridge which separates it from the redwood belt on the east. At Point Arena, Point Gorda, and Cape Mendocino the mesa is broader, as the redwood belt does not follow the coast line, which juts into the ocean at these points. The topography at the two latter-named places is exceedingly mountainous and the country correspondingly wild and sparsely settled.

THE MESA LANDS.

Soils.—The soils on the coast bluffs differ materially from those of the interior plateau and from those of the valleys. In many places, as on the bluffs at Point Arena and Fort Bragg, they contain a large admixture of blown sand, which renders them light and friable. Such soils are often poor in quality and unfitted for the production of good grass crops, except where they have been fertilized.

By heavy manuring every other year good crops of red and black oats are produced. The second year stock are grazed on the "volunteer" crop, or the ground is planted with potatoes, which are well suited to the soil conditions. The soil also seems to be well adapted to carrots, mangel-wurzel, and cabbages, which are grown as fall feed for cows.

These poorer sandy lands are usually characterized by growths of the dwarf native pines, *Pinus muricata* and *P. contorta.*

Between Manchester and Greenwood, and particularly on a strip of land some 3 miles long near Miller, a richer and apparently deeper soil occurs, producing splendid crops of wheat, barley, and other farm produce, and proving well adapted to the cultivation of beans and potatoes. Sweet peas, field peas, edible peas, cabbages, and other horticultural crops, in spite of the foggy summer climate, are here grown as seed crops for the San Francisco market. Some 80,000 bushels of grain and 1,500 tons of hay are reported as having been produced in this vicinity in 1899.

Grasses and other forage plants.—As before noted, perennial grasses are relatively more abundant in numbers, both of species and individuals, along the coast than in the interior. On account of the length of time occupied by the inland journey and the occurrence of an exceptionally dry season, the writer's coast trip was made too late in the season to find all the grasses in condition to collect, and the determination of some of the most important of them has therefore to be left to a future occasion.

Danthonia californica, *Festuca rubra* var., an undetermined species of *Poa*, *Calamagrostis aleutica*, *Deschampsia cæspitosa* and *D. holciformis* are the prevailing grasses, danthonia being the most abundant

and often forming a dense turf of excellent pasturage. The ray grasses, perennial, Italian, Australian, and many-flowered, have been introduced and are now freely naturalized in many localities, adding materially to the value of the uncultivated forage. Soft chess is met with but sparingly.

Bull clover (*Trifolium wormskjoldii*) is common in springy places, and bear clover (*T. fucatum virescens*) on slidy, clay soils on the higher ranges; these two are considered as among the best native forage plants. White clover (*T. repens*) has become established along roadsides; bur clover (*Medicago denticulata*) and black medic (*M. lupulina*) are sparingly naturalized. Red clover (*T. pratense*) has become naturalized in a few localities.

California lotus (*Lotus americanus*) is commonly met with in dry places among brush and on the open ranges on Bear River Ridge. Rib grass (*Plantago lanceolata*) is naturalized in several places, and furnishes a small quantity of late summer feed.

A variety of red fescue forms a somewhat sparse turf on the sandy summits of the cliffs. In crevices and on ledges of the rocky cliffs *Calamagrostis aleutica*, *Agrostis densiflora*, *Poa unilateralis*, and species of *Bromus* and *Elymus* hold the soil in company with such maritime plants as *Erigeron glaucus*, *Mesembryanthemum æquilaterale*, *Lupinus michenerii*, etc.

The cooler and moister summer climate of the coast induces the forage plants to keep green two or three weeks later than on the interior ranges; they are at their best in the months of May and June. The yield of forage diminishes seriously toward the end of July, and the feeding of dairy stock with forage crops then begins. At Point Arena some dairymen commence feeding with field peas, which are fed green, following with root crops, of which carrots and mangelwurzel are principally used. The improved strains of cattle parsnip are well worth trial in this section.

Few sheep are now run on the mesa lands; cattle are raised throughout the belt, there being a steady demand for beef in the lumber camps of the adjacent redwood region.

The high bluff lands of Cape Mendocino, from Bear River Ridge to the Upper Mattole, furnish probably the finest perennial stock ranges of Humboldt County. Danthonia forms a large part of the forage, and perennial ray grass has become established in many spots, adding much to the early winter feed. Rib grass is occasionally met with and furnishes a small amount of late feed, but it is of very little value for cattle. Our visit was made too late in the season to find the native grasses in condition for collection and determination.

Orchard grass and oats are successfully cultivated on these hills, and are used both for hay and silage, two or three silos having been built during the last two years. Several creameries are in use, the butter being carried a distance of 10 to 15 miles to the nearest rail-

road for shipment to Eureka, whence it is sent down to San Francisco by steamer.

The Cape Mendocino ranges are in greater need of early winter-growing grasses than of summer grasses, differing entirely in this respect from the ranges of the interior. The species which seem most likely to answer this need are: Many-flowered millet grass (*Oryzopsis miliacea*), reed fescue (*Festuca arundinacea*), Texas blue grass (*Poa arachnifera*), tall oat grass (*Arrhenatherum elatius*), Japanese wheat grass (*Brachypodium japonicum*), rescue grass (*Bromus willdenowii*), awnless brome grass (*Bromus inermis*).

THE WHITE-ASH PRAIRIES.

On the ridges which separate the smaller coast streams, e. g., the Noyo and Albion rivers, are found the "white-ash prairies," or "white plains," which are almost confined to this part of the State. They do not cover the whole of a ridge, but predominate near its western extremity where the sandstones outcrop. As its popular name implies, the soil on these prairies is white and powdery; it quickly works up into a thick dust resembling white wood ashes. It is about a foot in depth, overlaying a sandstone of very loose texture, and is said to be so impervious that after water has been allowed to stand for two weeks it scarcely penetrates more than an inch or two. A preliminary examination, kindly made by Prof. R. H. Loughridge, of the agricultural experiment station at Berkeley, shows that this soil contains a high percentage of humic acid and a low percentage of phosphates and mineral matter; the subsoil (sand) is weak in phosphates. Dr. Loughridge points out that on such soil grain crops could not be expected to live, though a few of the hardier grasses might succeed, and that liming the soil would probably improve it, counteracting the excessive acidity.

As might be expected of a soil with such marked peculiarities, it is characterized by a distinctive flora; such trees and shrubs as attain a normal height on adjacent soils become dwarfed to almost pigmy size on these white plains; the species most frequently met with are: Tan-oak (*Quercus densiflora*), Prickle-cone Pine (*Pinus muricata*), Coast Scrub Pine (*Pinus contorta*), Gowan Cypress (*Cupressus goveniana*), Chinquapin (*Castanopsis chrysophylla*), Salal (*Gaultheria shallon*), Huckleberry (*Vaccinium ovatum*), Rhododendron (*Rhododendron californicum*), Myrica (*Myrica californica*), Labrador Tea (*Ledum glandulosum*), Manzanita (*Arctostaphylos nummularia* and other species) and species of *Ceanothus*.

Sub-shrubby and herbaceaous plants are also dwarfed; the following are common: *Polygala californica*, *Helianthemum scoparium*, *Xerophyllum tenax*, *Hypericum concinnum*, *Gentiana menziesii*, *G. oregana*, *Lilium maritimum*, *Panicum unciphyllum*, *Agrostis pringlei*, and *Lotus leucophæus*.

Perhaps owing to the sandy and impervious nature of the soil, sphagnum and peat swamps have formed in the low hollows on the plains, a particularly remarkable feature at such a low altitude, and especially so as neither peat nor sphagnum are known to us as occuring elsewhere in the Coast Ranges of northern California. The plants most commonly met with in these swamps are: *Ledum glandulosum* (the prevailing species), *Lomaria spicant*, *Gaultheria shallon*, *Myrica californica*, *Veratrum fimbriatum*, *Viola sarmentosa*, *Trientalis europæa latifolia*, *Sisyrinchium californicum*, *Lotus formosissimus*, *Cornus canadensis*, *Hypericum anagalloides*, *Gentiana menziesii*, *Poterium officinale*, *Phalaris cœrulescens*, *Drosera rotundifolia*, *Campanula linnæifolia*, *Calamagrostis aleutica*, *C. bolanderi*, *C. crassiglumis*, *Agrostis pringlei*, *Juncus bolanderi*, *J. falcatus paniculatus*, *J. supiniformis*, several species of *Carex*, among which (according to Boott [a]) occur the following: *C. phyllomaniaca*, *C. mendocinensis*, *C. vallicola*, *C. sterilis*, *C. salina mutica*, *C. livida*, *C. polymorpha*, *C. gynodynamia*, and *C. luzulina*. The grasses are remarkably few both in species and individuals.

According to the State Survey Botany,[a] the sphagnum moss appears in the three species, *Sphagnum cymbifolium*, *S. mendocinum*, and *S. subsecundum longifolium*.

Other plant species occur on the plains and in the sphagnum swamps, but are generally less abundant or less noticeable. An analysis of the flora as above listed shows that its most characteristic feature does not consist so much in the presence of endemic species as in the commingling of the adjacent redwood and coast floras, with the addition of species commonly found in thin soils at comparatively high altitudes, and of certain peculiarly boreal species, rarely if ever found at other points in the Coast Ranges, and when met with elsewhere in the State, usually occurring at very much higher altitudes. The phenomenal feature is, therefore, the occurrence of several species belonging to high altitudes and latitudes, along a narrow coast mesa not more than 200 feet above sea level, and between the thirty-ninth and fortieth degrees of north latitude. (All the species here listed with the exception of *Arctostaphylos uva-ursi* were collected between the Navarro and Tenmile rivers).

To make this point clearer we may classify them as follows:

Plants met with on comparatively dry ridges at various altitudes in the redwood belt: *Cupressus goveniana*, *Quercus densiflora*, *Polygala californica*, *Castanopsis chrysophylla*, *Xerophyllum tenax*, *Gaultheria shallon*, *Vaccinium ovatum*, *Hypericum concinnum*, *Helianthemum scoparium*, *Rhododendron californicum*, *Ceanothus* spp., *Myrica californica*, *Arctostaphylos nummularia*, and other species.

Plants of moist, shady spots in the redwood belt: *Viola sarmentosa*, *Trientalis europæa latifolia*.

[a] Brewer, Watson, and Gray, Publications of the Geological Survey of California, Botany, 2 Vols., 1876 and 1880.

Coast-bluff species: *Pinus contorta*, *P. muricata*, *Calamagrostis aleutica*, *Phalaris cœrulescens*, *Sisyrinchium californicum*, *Lotus formosissimus*, *Gentiana oregana*.

Boreal plants: *Cornus canadensis*, *Arctostaphylos uva-ursi*, *Juncus supiniformis*, *Hypericum anagalloides*, *Poterium officinale*, *Drosera rotundifolia*, *Lomaria spicant*, *Ledum glandulosum*, *Sphagnum mendocinum*, *S. cymbifolium*, *S. subsecundum longifolium*, *Carex vallicola*, *C. salina mutica*, *C. livida* (reported from "peat bogs and pine barrens from New Jersey and New York to Labrador and Lake Superior and high northward Alaska").

Species apparently endemic: *Veratrum fimbriatum*, *Lilium maritimum*, *Campanula linnœifolia*, *Carex phyllomaniaca*, *C. mendocinensis*, *C. gynodynamia*, *Agrostis pringlei*, *Calamagrostis bolanderi*, *C. crassiglumis*.

Attempts to cultivate the white-ash prairie lands have been made with great labor and little result. Oats, potatoes, beans, peas, corn, and cabbages will grow fairly in the best spots, and velvet-grass (*Holcus lanatus*), a little ray grass, and squirrel-tail seem to thrive; orchard grass is said to grow but poorly. Tall oat grass would probably thrive as well as the velvet grass and make a more valuable crop. Taken all in all the conditions are very unpromising for the production of agricultural crops, and it is doubtful whether the land would ever pay for the cost of clearing and breaking. Danish settlers claim, however, that it would make good farm land if laid down to some pasture grass, grazed first with horses, second with cows, third with sheep, and finally plowed and treated with all the stable manure available. The writer could not find that any one of them had tried to put this precept into practice, however, and it is at best highly doubtful whether any good pasture grass could be induced to grow there.

The native vegetation of the white-ash prairies furnishes almost as clear an indication of the physical and chemical nature of the soil as do the alkali weeds in the Great Valley Region and the Colorado Desert. The poor soils are invariably indicated by the low stature of such shrubs and trees as grow more luxuriantly on adjacent areas of good soil, particularly salal, chinquapin, cypress, *Xerophyllum*, and bracken, and the presence of labrador tea, *Lomaria*, and *Arctostaphylos nummularia*.

BOTTOM LANDS.

Alluvial lands are not commonly met with in northwestern California on account of the mountainous nature of the country. The principal alluvial areas in the coast section are the bottom lands of Eel River, with its broad flood plain, the flood plain which fringes Humboldt Bay, and the bottom lands of Smith River. A small cultivated area of bottom land occurs at the mouth of the Garcia River.

A few acres of unreclaimed salt marsh are also found at the mouths of the Noyo and Ten-mile Rivers.

Soils.—On the flood plains at the mouth of Eel River and the other streams emptying into Humboldt Bay, we find the richest agricultural soils of the region. As already pointed out these flood plains are not delta deposits, but are the result of corrasion of the rocks of the wild-cat formation. Until within recent years they have been subject to tidal inundation, but a large portion has been reclaimed from the ocean by means of embankments. There still remain large areas of unreclaimed salt marsh, however.

The fertility of these bottom lands is a source of constant wonder to those unacquainted with the prevailing conditions. To quote again from the Pacific Rural Press:

> Mr. A. Kansen, of Ferndale, keeps 35 cows on 34 acres, secures an average yield of 300 pounds of butter, and buys no feed whatever. The cows are on pasture nine months of the year, and for the other three are fed hay and roots, all grown on the 34 acres. J. E. Brown, also of Ferndale, keeps 35 cows on 40 acres, his average yield and feeding being like the preceding. These records are strictly credible when one knows the natural pasturage conditions prevailing and the favoring climate for the growth of supplementary succulent food supplies. The cows are simply good selected grades of dairy breeds. The average in the dairy sections of Humboldt County—that is, on the best of the valley lands—is said to be 1½ acres to the cow.

Forage crops.—The principal forage crops are red clover, oats, and Italian ray grass for hay, peas, and a little corn for soiling, and mangel-wurzel (locally known as "beets") and carrots for root crops. Some alfalfa is now grown both for pasturage and hay, and barley for ensilage. Stock are frequently pastured on red clover. Dutch clover has taken possession of many of the pastures.

Red clover is considered by far the best and most productive crop, but farmers complain that after some years of successful growth it "runs out" and can not readily be started again. As Professor Hilgard has repeatedly pointed out to them, this is undoubtedly due to excessive acidity of the soil, induced by lack of lime, and can doubtless be remedied by liming. A deposit of lime has been found on Jacoby Creek, between Eureka and Arcata, which promises to solve the difficulty and to render the continued successful cultivation of red clover a possibility. The following method of treatment is recommended by Professor Hilgard, who writes to the Eureka Watchman, as follows:

> Relative to the amount of lime to be applied to your sediment lands I would say that half a ton is about the minimum from which you can expect any prompt results, and from 1 to 2 tons is the usual gauge in such cases. However, the best amount varies materially in different lands; and, as yours contains so little clay, I should say the smaller dressings might be adequate if repeated, rather than using at once the 4 or 5 tons commonly prescribed in the old country.
>
> The way they use it there is to haul it in piles, let the rains slake it, and when dry enough spread with shovels, much as you would stable manure; then harrow or cultivate in; but any way to spread it uniformly will do. It can be made into

whitewash and filtered from a cart tank, as is commonly done in Holland. It should not be allowed to air slake, as in that case it loses some of its efficacy, and its action becomes slower. Of course it should be understood that quicklime will injure seeds and plants with which it comes in direct contact. It should be applied on the bare soil, and is especially useful if put on top of a green manure crop or sod turned under. After a few weeks it becomes sufficiently mild to be innocuous to seeds unless applied in very large amounts. In the case of orchards or vineyards small successive doses—say half a ton to the acre—are preferable to heavy applications.

Complaint is also made that it is difficult to get a good stand of red clover on newly plowed land. This difficulty can be largely overcome by sowing Italian ray grass and red clover together. The grass serves as a nurse crop for the clover, increases the yield of hay during the first two years, and gradually "runs out," leaving a good stand of clover.

Land values.—While upland grazing lands in large tracts vary in price from $4 to $15 per acre, according to location, carrying capacity, etc., the rich bottom lands of the Lower Eel River Valley, near Arcata, and at Salmon Creek, Elk River, and Jacoby Creek are held at from $75 to $300 per acre, according to location and state of improvement.[a] Well-improved farms, fully seeded to red clover, pay good interest on the latter sum. The best farm lands near Ferndale are said to command $500 per acre, and are hard to obtain at the price.

SAND DUNES.

Dunes of drift sand of greater or less extent are found throughout the California coast. Wherever they occur they prove detrimental to agricultural interests, not only representing so much waste land which might otherwise be utilized, but surely, even if slowly, spreading, and sometimes completely ruining what might have been the best of farm lands. On account of the slowness of their encroachment, however, farmers and landowners are often indifferent to the damage being done.

The principal sand dunes of the coast of northwestern California occur at the following points:

At the mouth of the Garcia River at Point Arena, on the Sheppard Ranch. Though not extensive at this point, they are steadily encroaching on the limited area of rich river-bottom land, and have already done no little damage.

Between Pudding Creek near Fort Bragg and the mouth of the Ten-mile River, some 10 miles north, occur the worst cases on the whole of the coast area which came under our observation. At Inglenook it is said that the dunes have encroached on good farm land to the extent of 500 feet in two years. At Cleone a half acre of orchard has been ruined, the trees having been almost wholly covered with sand in four years' time. A ranch house has had to be moved and the

[a] Resources of California, San Francisco, September, 1900.

FIG. 1.—A LAGOON AT CRESCENT CITY, CAUSED BY DRIFTING SAND, WHICH HAS FLOODED A LARGE AREA OF PASTURE LAND.

FIG. 2.—YELLOW SAND-VERBENA (ABRONIA LATIFOLIA), OF SOME USE AS A SAND BINDER.

county road diverted in order to avoid the dunes, which at this point are of great size.

At Eureka the peninsula which almost incloses the harbor (see Map III) is chiefly composed of sand dunes, which do not, however, encroach on the mainland, though possibly doing some damage to the harbor itself by silting up the channel.[a]

The conditions at Humboldt Bay are described in the following extract:[b]

> Humboldt Bay is 14 miles in length and from one-half mile to 4 miles in width. It has a tidal area of 28 miles and 35 linear miles of navigable channels. It is situated near the center of the coast line of Humboldt County and extends nearly parallel therewith, being separated from the ocean by two narrow peninsulas of sand. Being so completely landlocked, this harbor is of the utmost importance to a coast so barren of good harbors as is the Pacific; but its usefulness has in the past been seriously impaired by shifting sand bars, which obstructed its entrance, and by the shallowness of some of its inner channels. In 1889 the General Government began improving the entrance to the harbor by extending two jetties of rock, one on each side of the channel, so as to confine the waters to a permanent way. This work was completed in September, 1899, at a cost of more than $2,000,000.
>
> Eel River for a few miles of its lower course is navigable for small vessels, and has at several periods had regular steamer connection with San Francisco; but its navigation is often interrupted by the formation of sand bars at its mouth.

At Crescent City the mouth of a creek has been completely closed by drift sand, forming a large lagoon (Plate VI, fig. 1) and causing the winter flooding of extensive grazing lands. The protection afforded by a native pine forest appears to have prevented the encroachment of sand on the farm lands at this point. Should this timber be cut at any time for fuel, which is likely to be done as population increases and fuel becomes more scarce, a large tract of dairy land would be jeopardized. Precautions should be taken against such a result.

Big Lagoon, at the mouth of Maple Creek, Humboldt County, may perhaps have been formed in the same way as the lagoon at Crescent City.

Native sand binders.—The following native plants grow naturally on the sand dunes, and act to a greater or less extent as sand binders:

Abronia latifolia (yellow sand verbena) (Plate VI, fig. 2) is common at the mouth of the Garcia River; of some value as a sand binder on account of its heavy, prostrate stems and large, flat leaves, but not the best plant for the purpose, as it does not root at the nodes, and oftentimes the sand is blown away from beneath the branches, leaving the large, fusiform roots exposed to wind and sun.

Arctostaphylos uva-ursi is a prostrate species, forming large mats on almost pure drift sand on the sand spit opposite Eureka, where it

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[a] Since the above was written complaint has been received by the writer of serious injury to lumber mills caused by the drift sands at this point. Reclamation work has already been started by the planting of beach grass.

[b] "Resources of California."

becomes a valuable sand binder, rooting from the nodes. It fruits freely in such situations, readily producing its kind.

Bromus, sp., is a common grass on overgrown, sandy land at Samoa, near Eureka, helping to bind the drifting sand.

Convolvulus soldanella is not uncommon on the sand dunes, growing in almost pure sand, but apparently of little value as a sand binder, as it does not mat on the surface; the sand freely blows away from between the plants.

Corethrogyne californica obovata is a common species on the sand hills at Samoa, near Eureka, but of little economic value.

Elymus sp. grows luxuriantly in drifting sand at Samoa, making a promising sand binder. It is said to be eaten by stock while young and until about 14 inches high, when it becomes too coarse for forage.

Festuca rubra var., grows luxuriantly though not abundantly in drifting sand on the sand spit opposite Eureka. It might be used with advantage in company with *Poa douglasii*, as the one would to some extent complement the other. It also gives promise as a forage plant, but we have no data as to its actual forage value. At Samoa this variety seeds very freely, a quality lacking in many of our sand binders.

Juncus sp. is common in loose sand on the sand dunes of Humboldt Bay.

Poa douglasii (Sand-grass) is thoroughly at home in the drifting coast sands from San Francisco northward, but on the California coast is of little use as a sand binder, being too sparse in its growth to cover the surface, and too short of stature to check the drifts, which blow right over it, or out from under it, leaving the roots bare; these when exposed quickly dry out and die. In company with the variety of *Festuca rubra* mentioned above it might be used to advantage, as the one species to some extent makes up for the deficiencies of the other.

Tanacetum camphoratum is a common species on loose, drifting sand at Point Arena and Humboldt Bay.

Salix sp., a species of willow, is also common in some places, and at Inglenook has been planted as a check hedge, but with only partial success.

Elymus arenarius (Rancheria grass) occurs in sandy soils on Drakes Bay and Point Reyes, but was not collected within our limits. Though too sparse in growth to be of much value if used alone as a sand binder, this grass will doubtless prove serviceable if planted in company with other species.

Lupinus chamissonis (Blue lupin) is commonly met with from Point Arena southward and is of some use as a sand binder. The yellow tree lupin (*L. arboreus*) was not found north of Point Reyes. *Collinsia bartsiæfolia* occuring in drift sand near Cleone is an annual plant. Several other plants of lesser importance grow on the sand dunes.

FIG. 1.—BEACH GRASS AT POINT REYES, CAL.

FIG. 2.—PLANTING BEACH GRASS AT CAPE COD, MASSACHUSETTS.

Methods of preventing drifting and reclamation of waste dunes.—Although the above-named and other native plants grow freely on the dunes, no one of them proves thoroughly satisfactory as a check to sand encroachment. Almost all of these species grow so slowly and so sparsely as to allow the sand to blow away from their roots, which die on exposure. They are, moreover, too dwarfed in stature to check the drifts successfully. Therefore, if the drifting is to be checked and the waste dune areas are to be made useful, it is necessary to remedy this defect. The first point to be gained is to render the surface as nearly stable as possible, in order that useful plants may have a place on which to grow. For this purpose the cultivation of certain selected sand-binding plants has been adopted, in Europe and in the Eastern States, as being the cheapest and most satisfactory means of checking and reclaiming drift sands. The following are considered the most satisfactory sand binders:

Beach grass (*Ammophila arenaria*) (Plate VII) was introduced at Point Arena some ten years ago by Mr. Sheppard, a few plants having been obtained from the commissioners of Golden Gate Park, San Francisco, who had successfully used it at that place (Pl. VIII, fig. 2).

It has thriven admirably at Point Arena, and now covers about an acre of the dunes. This grass is by far the best sand binder tried on the California coast, its dense growth, long under-ground stems, and long tufts of leaves preventing the sand from blowing away from the roots. Moreover, the banking up of sand does not in any way injure the plant, which continues to lengthen its stem and throw out new roots as fast as the sand piles up around it. Professor Scribner states that "a plant will, by gradual growth upward, finally form stems and roots sanded in to the depth of fully 100 feet."

Beach grass is most successfully propagated by transplanting in the autumn. Vigorous plants are selected and pulled up by hand. Usually a bundle of half a dozen plants is held together by one man, while another makes a hole in the sand. This hole should be 18 inches deep, and is made with a long spade or shovel which is forced into the sand and then pressed forward, making an opening into which the beach-grass roots are thrust; the spade is then withdrawn and the sand pressed close about the roots. The grass is not planted in rows, but in quincunx, or irregular order, 1 and 2½ feet apart, according to the slope.[a] In California the planting should be done in the early fall, as the growth of roots is greater at that season, and the chances of success are consequently increased. Moreover this gives the plants the full benefit of warm soil, and of the whole season's rainfall. If sown in the spring, there is danger of the young plants drying out or burning up during the summer months. On the California coast the sow-

[a] Scribner, F. L. Economic Grasses; U. S. Dept. Agric., Div. Agros., Bul. 14. 1898: Scribner, F. L. Sand-binding Grasses; reprint from Yearbook Depart. Agric. 1898.

ing of seed usually proves unsatisfactory, as the seed is either buried too deeply by the drifting of the sand, or blown away by the strong trade winds.

The main objection to beach grass is the cost of planting. In Belgium, Scotland, and England, and on the coast of Massachusetts, however, the importance of reclamation has been considered to far outweigh the initial cost of planting, and hundreds of acres have been systematically planted according to the method described above. At Cape Cod, on the Massachusetts coast, some 90 acres were planted in three years, from 1895 to 1898. The cost amounted from $60 to $65 per acre, requiring 15 men and 1 horse about two days, working nine hours per day, to cover an acre with plants. On the California coast, where land is still cheap and labor costly, the farmers claim that they can not afford to pay so much for the reclamation of sand dunes.

On some portions of the English coast the work of sand-dune planting is performed by the municipal or other local governments. Heavy penalties are inflicted for pulling up or otherwise removing a single plant. This appears to be the most just method of treating what is more than a private nuisance. It does not seem fair that a farmer or private landowner should be compelled, in order to save his land, to pay for the planting of many acres of sand dunes which do not belong to him and from the use of which he can derive little or no profit. It seems more just that the duty of reclamation should devolve upon the public.

Sea lyme grass or Rancheria grass (*Elymus arenarius*), which is sparingly found in sandy places along the California coast from Santa Cruz northward, is a sand binder of only medium quality and is recommended for cultivation in company with beach grass. Professor Scribner states that "these two grasses when combined seem admirably adapted for the purpose of forming a barrier to the encroachment of the sea. The sand that the beach grass arrests and collects about itself the lyme grass secures and holds fast." It has little, if any, forage value.

Utilization of sand dunes.—The question is often asked how sand dunes may be utilized and what forage plants will grow upon them. Beach grass and sea lyme grass, though sometimes grazed when very young, can not be considered as forage plants. It has been stated that awnless brome grass (*Bromus inermis*), broncho grass (*B. maximus gussoni*), and *Bromus sterilis* will grow well in such situations; but their culture as sand binders is only in the experimental stage, and their nutritive value appears to be comparatively low. Bull clover (*Trifolium wormskjoldii*), one of the best of the native California clovers, makes a dense turf and luxuriant growth (sometimes knee-deep) in low, moist flats between the dunes, but does not appear to grow on the dunes themselves. *Atriplex halimoides*, one of the Australian

saltbushes which seems well adapted to the cool summer climate of the coast, is worthy of trial in these situations. It is a valuable forage plant and seeds freely, but we have not yet demonstrated whether or not it will stand trampling. On the Santa Barbara coast sand dunes it has been found that *Eriogonum fasciculatum* and *Lotus glaber*, two native perennial plants, grow luxuriantly through the dry season and produce an abundance of nourishing feed which is much relished by stock. It is doubtful, however, whether they would tolerate the climate of the northwest coast.

Hairy vetch (*Vicia villosa*) is recommended for experimental culture as a sand binder, on account of its rapid and luxuriant growth and ready propagation by seed, but we are not aware that its value for this purpose has been determined. It is an excellent forage plant, and is becoming naturalized in some parts of the State.

Modiola (*Modiola decumbens*) has been found useful on the alkali soils of the interior, and is said to be greedily eaten by stock. If it will tolerate the cooler summer climate of the seashore, and the loose, light soil of the sand dunes, it will make a valuable addition to the list of sand-binding plants, as it roots freely from the joints and spreads rapidly, forming a dense mat of herbage.[a]

New Zealand spinach (*Tetragonia expansa*) is a succulent beach plant, said to be eaten by stock. It has already become naturalized on the sandy seabeaches along the coast in the vicinity of San Francisco.

Tree mallow (*Lavatera assurgentiflora*), native of Anacapa Island, has been successfully used in San Francisco for the last fifty years as a sand binder, wind break, and ornamental shrub. It grows to a height of 6 to 12 feet, and thrives on light, sandy soil; it is also valuable as a forage plant, cattle browsing greedily on the foliage.

It does not appear that sand-binding qualities and forage value are usually combined in the same plant, but it is possible that when once reclaimed some forage crop might be raised on the dunes. It is an open question, however, whether stock feeding on sand dunes should ever be practiced on account of the danger of starting fresh drifts. Mr. Sheppard, who has farmed at the mouth of the Garcia River for nearly forty-five years, traces all his trouble with drift sand to the time, some twenty-five or thirty years ago, when a neighbor of his commenced sheep raising on the dunes, tempted to do so by the high price of mutton and wool. In his eagerness to make money while the prices were up, this man overstocked and left the sand almost bare, with the result that it began to drift for the first time within Mr. Sheppard's memory. Profiting from this experience the latter gentleman has kept his stock off the dunes for some time, with the result that a new growth of sand grass, sand verbena, blue lupine,

[a] Since the above was written this plant has been found growing wild at Tomales Bay, along the coast.

rush, willow, etc., is starting. But none of these plants checks the sands in the "drifts," and more vigorous measures of reclamation must be adopted if his alluvial bottom lands are to be saved.

Beach grass makes an excellent and very durable thatch, and has been used for the manufacture of coarse paper.

Esparto (*Stipa tenacissima*) and albardin (*Lygeum spartum*) are worth trial on these dunes, as they have proved well adapted to the climate at Berkeley. They are natives of the sandy shores of southwestern Europe and northern Africa, and are tall perennial grasses, with long, stiff, and very tough leaves, from which ropes, baskets, mats, hats, and other articles are woven. The leaves are employed largely in England and in this country in the manufacture of paper, for which purpose they are superior to straw. Esparto is one of the most important articles of export from Algeria, and more than 2,000 tons are annually shipped from northern Africa and Spain to Great Britain. "Ten tons of dry esparto, worth from $18 to $25 per ton, can be obtained from an acre under favorable circumstances." These grasses may be cultivated either by seeds or by division of the root; but the latter is the more common method. Specimens for trial are offered by the director of the agricultural experiment station at Berkeley. (See Pl. VIII, fig. 1.)

At Cape Cod it has been found possible to raise fine growths of pine trees and shrubs on the dunes within three years after the first planting with beach grass. The species used were a native pine (*Pinus rigida*), Scotch pine (*P. sylvestris*), seaside pine (*P. maritima*), and Austrian pine (*P. austriaca*), Scotch broom (*Genista scoparia*), and bayberry (*Myrica cerifera*). (Pl. VIII, fig. 2.) All of these would probably thrive equally well on the coast of northwestern California, but it is not necessary to import trees for the purpose, as the native coast pines, so common in the region, would answer as well or better and make fuel of an excellent quality. Of these the most valuable for this purpose would be the Monterey pine (*Pinus radiata*) and the prickle-cone pine (*P. muricata*). The scrub pine (*P. contorta*) is also valuable, particularly as a wind-break. Some of the rapidly growing Australian acacias, particularly *A. longifolia sophoræ* and *Albizzia lopantha*, are also satisfactory as nurse trees, wind-breaks, and for ornamental effect. Such trees and shrubs can easily be raised when once the beach grass is established by scattering seeds among the tufts of the latter. In addition to their value for fuel, such a growth of trees acts as a wind-break, an exceedingly useful feature in such localities.

THE REDWOOD BELT.

As before noted, the redwood belt consists for the most part of a dense forest of timber occupying a narrow strip of country immediately back of and almost parallel with the coast. Owing to the immense

FIG. 1.—VIEW IN GRASS GARDEN, AGRICULTURAL EXPERIMENT STATION, BERKELEY. ALBARDIN AT THE RIGHT.

FIG. 2.—SAND DUNE RECLAMATION AT CAPE COD, MASSACHUSETTS, SHOWING PROTECTIVE COVERING FORMED OF BEACH GRASS (AMMOPHILA ARENARIA (L) LINK).

size of the trees and their abundance, the forest shade is here very dense. On the bottom lands few other species of trees are met with. On the ridges forming watersheds between the different forks of the coast rivers the redwoods are more scattered, and other species of trees, together with some brush, occur more frequently.

Grasses are scarce in the redwood forest, *Bromus lævipes*, *Melica bromoides*, *Savastana macrophylla*, *Trisetum canescens*, and *Deschampsia elongata* being the prevalent species. These grow mainly near the borders and openings of the forest, and provide only scant feed for stock. The rare but characteristic *Asperella californica*, found in the redwood belt near San Francisco, does not appear to occur as far north as Mendocino County.

Forage plants other than grasses are not plentiful, and are principally eaten by hogs and other stock as a change of diet from excessively luxuriant range feed. Of these the following are noteworthy: Squaw lettuce (*Claytonia perfoliata*) is said to be a favorite food of cattle and hogs. Thistles (*Carduus* spp.) and the tubers of wild horseradish (*Dentaria* sp.) and roots of bracken (*Pteris aquilina lanuginosa*) are eaten by hogs. *Oxalis oregana* is sometimes eaten in small quantity by cattle and horses. The common sword fern (*Aspidium munitum*) is said to be eaten readily by calves and stock for a day or two after feeding on clover on the ranges. Hogs doubtless also feed on salal-berries (*Gaultheria shallon*) and huckleberries (*Vaccinium ovatum*), which are abundant in the redwood forest, and on the bulbs of liliaceous plants. Acorns of *Quercus densiflora*, chinquapin nuts, manzanita berries, and some deer brush are found on the higher ridges.

The introduction of tall oat grass, rescue grass, awnless brome grass, and wood meadow grass (*Poa nemoralis*) on the higher dry ridges might increase the amount of forage. It is not likely that any valuable forage plants will be found to thrive in the forest itself; nor would it be desirable from the point of view of the lumberman and forester to attempt to turn the forest proper into pasture land, the two interests being diametrically opposed.

When cleared, this redwood land, where not too steep, makes good pasture if sown to orchard grass and white clover. On account of the astonishing vitality of the redwood stumps, however, it is found necessary to go over the ground at least once a year chopping off suckers in order to keep the land clear. It is said that if this is done at the end of July or early in August it is only necessary to do it once a year, but that if cut at any other season the operation has to be repeated one or more times during the year.

The narrow strips of bottom land, where cleared of timber, produce excellent forage and general farm crops.

FODDER CROPS.

FODDER CROPS NOW CULTIVATED.

The principal fodder crops cultivated in the region are noted here. Oats is the most extensively grown hay crop. Next in importance are red clover, wheat, barley, Italian ray grass, alfalfa, and velvet grass. Small quantities of timothy, many-flowered ray grass, orchard grass, and rye are also used. Mixed hay crops are seldom, if ever, grown. Wild hay is mown in a few mountain valleys, and the wild oats on the hillsides are sometimes made use of in the same manner.

For soiling and ensilage field peas, red clover, alfalfa, corn, oats, and barley are grown. Tares, alsike, sainfoin (esparcette), and crimson clover do not appear to be used.

For root crops carrots are most commonly grown. Mangel-wurzel is being tried in one or two places along the coast. Turnips and parsnips do not appear to have been tried. The climate is probably too dry in summer for turnips, except in the extreme north.

PLANTS RECOMMENDED FOR CULTIVATION OR TRIAL.

Beach grass (*Ammophila arenaria*) is an invaluable grass for checking the spread of drift sands. The method of planting is discussed on page 59.

Black medic (*Medicago lupulina*) (fig. 1) seems to be well adapted to the climatic conditions of this region, as it has become thoroughly naturalized and grows luxuriantly in several localities. It is considered a useful pasture plant for wet meadows.

FIG. 1.—Black medic (*Medicago lupulina*).

Of blue grama (*Bouteloua oligostachya*) Professor Scribner writes as follows:

> It is a perennial, 6 to 18 inches high, its strong rhizomes and numerous root leaves forming dense and more or less extensive patches of excellent turf. * * * It frequents the bench lands of Montana, growing at elevations of from 3,000 to 4,000 or 5,000 feet, and not infrequently covers wide areas. No other grass better withstands the trampling of stock, and it is unsurpassed for grazing purposes. In the early days in the Southwest it formed a large proportion of the hay delivered at the various military posts and stage stations and was considered the best obtainable there. Like the buffalo grass, it cures during the dry season in the turf into perfect hay, losing none of its nutritious properties.

It has given satisfactory results at Berkeley, and is a very promising grass for dry, open upland ranges.

Buffalo grass (*Bulbilis dactyloides*) is low growing, rarely more than 5 or 6 inches high, producing numerous creeping and widely spreading branches, which root at the joints, each joint producing a new plant. In this manner it rapidly spreads over a wide area, forming a close mat of fine-leaved herbage greatly relished by all grazing animals. At Berkeley buffalo grass is a summer grower, not starting before April, but continuing green till late in the fall. It withstands drought well, and on this account would probably form a valuable addition to the summer pasture of the upland ranges, supplementing the winter feed of the prevailing annual grasses. Seed is not easily obtained, but the plant is readily produced by roots, which should be planted in early spring and protected from stock till well established. Small quantities of roots can be obtained on application to the Director of the Agricultural Experiment Station, Berkeley.

FIG. 2.—Bur clover (*Medicago denticulata*)

Bur clover (*Medicago denticulata*) (fig. 2) is one of the most nourishing forage plants for late summer feed. Cattle do not touch it early in the season, so that it has opportunity to mature large quantities of its prickly seed pod (burs). When ripe the seeds are said to contain a large proportion of nutritive matter and are eaten with great avidity by stock, either from the plant or licked up from the ground after falling, in July, August, and September, the season when green feed becomes most scarce. Cattle placed on stubble in which there is an abundance of bur clover become exceedingly fat at this season of the year. As the burs become badly entangled in the wool of sheep, this plant is not desirable for sheep ranges, but in its stead the closely related smooth bur clover might be grown.

Bur clover is said not to thrive so well on the drier uplands back from the coast, but it is nevertheless worth trial in such situations. It luxuriates in the comparatively moist valleys. It is best sown by scattering the burs over the ranges in autumn, as they will germinate and take root with the advent of the first rains. It is not necessary to harrow the ground or to cover the burs, unless they are sown in

spring. The burs are offered for sale by San Francisco seedsmen, or can readily be collected in great quantity in the counties around San Francisco Bay, where it is abundant.

California lotus or Dakota vetch (*Lotus americanus* or *Hosackia purshiana*) (fig. 3), on account of the lateness of its growing season, is considered valuable as a range forage plant, helping to fill the gap between the drying up of the ripened annual grasses and the starting of the new autumn growth. It is thoroughly at home on dry upland ranges, occasionally growing even among chaparral. Seed of the California lotus is not on the market and must be collected in its native habitat.

FIG. 3.—Dakota vetch (*Lotus americanus*).

Creeping bent (*Agrostis alba stolonifera*) is a valuable perennial pasture grass, making a good bottom growth. On account of its running rootstocks it is useful for mixing with less distinctly turf-forming species. It is not a productive hay grass. Creeping bent requires a moist soil, and is most likely to succeed in the mountain valleys.

Diss (*Ampelodesmos tenax*) is a tall, coarse species from the arid regions of North Africa which was introduced by the Agricultural Experiment Station at Berkeley a few years ago. Seeds of this plant were later received from Professor MacOwan, of the Agricultural Department of Cape Colony, as of "a forage plant;" shortly afterwards the writer learned through a correspondent in Lake County that he had received seed of the original distribution made by the station and that the plant had proved remarkably successful with him, producing a great deal of forage on dry, chaparral-covered hillsides where no other forage plants would grow, and that it was greedily eaten by stock.

Field peas (*Pisum arvense*) are already grown along the coast for feeding to dairy cows during the dry summer months. Still greater use can be made of this sweet, palatable, and very nutritious fodder plant with the increasing use of the silo, as it makes an excellent quality of ensilage. As a ration for stock, ensilage of oats and peas mixed is considered almost unrivaled. Some reported failures with trial crops of field peas are probably due to the use of weevil-damaged seed, and careful examination of the seed should be made before pur-

chasing, to avoid disappointment. Peas and oats (or rye) for ensilage may be sown together, as the former will climb up and help to support the latter.

Hard fescue (*Festuca duriuscula*) is a valuable pasture grass on dry, sandy soils unfit for the growth of better grasses, as it resists long periods of summer drought. Although it is a bunch grass, not producing a turf, it can be used to advantage in mixtures with other grasses. It grows well at Berkeley.

Johnson grass (*Andropogon sorghum halepensis*) in the Southern States yields a good crop of hay, which is said to be much appreciated by stock, but in the coast region of middle and northern California it has not given great promise as a hay grass. When once established it becomes one of the most troublesome and most difficult weeds to eradicate from cultivated ground. The root-stocks are produced in great abundance, literally filling the soil; they develop very rapidly, are fleshy, and are said to be much liked by hogs. It would be well worth trial in openings among the redwoods on the headwaters of the Noyo and Navarro rivers, where large bands of hogs are raised in the woods. If seeds and pieces of root were carried down these smaller coast streams, they would not be likely to do any damage to farm lands, on account of the narrowness and depth of the gorges through which they empty into the ocean and the absence of broad alluvial flood plains. It appears unwise, however, to introduce Johnson grass along the headwaters of Eel River, on account of possible injury to the valuable farm lands at the mouth of that river; being one of the richest sections of the whole region of northwestern California, deterioration of land values there would tend to increase taxation over the rest of the region. Johnson grass has been tried with only unsatisfactory results in dry, arid soils in California.

Hairy vetch (*Vicia villosa*) is being strongly recommended as a forage crop on account of its vigorous growth and high nutritive value. Smith states that hairy vetch is an excellent soiling crop, one of the best that has been introduced into the United States, although, on account of the high price of the seed and the large amount which must be sown per acre, it has not been widely cultivated. The seed should be sown at the rate of a bushel and a half per acre. The nutritive value of the hay is high, analyses by Coudon in 1890 showing 23 per cent of crude protein. The yield varies from 1½ to 4 tons per acre, according to the fertility of the soil. Hairy vetch has proved well adapted to the climate of Berkeley. It might be sown with oats or rye for an ensilage crop, and is also recommended for trial as a sand binder, on account of its rapid growth.

Knot grass (*Paspalum distichum*). A valuable forage grass for overflowed lands, the margins of lagoons, lakes, and ponds. The yield varies considerably with the season; in wet years knot grass will yield a good crop of hay, but in dry seasons there will be scarcely enough

foliage for forage. The stems are somewhat succulent, and with the leaves, are tender and much liked by stock. In the marshy borders of the lagoons at Crescent City it has formed a valuable addition to the wild forage, and around Clear Lake it is said to have taken possession of the Tule lands within the last few years.

Meadow foxtail (*Alopecurus pratensis*), Professor Scribner says, "is a valuable grass for moist meadows and pastures, particularly the latter, on account of its early growth, being one of the earliest of cultivated grasses. It is very hardy and on good soil yields a large amount of excellent forage. In Europe it is regarded as one of the best pasture grasses. It should enter into all mixtures for permanent pastures, because it is very lasting, highly nutritious, and earlier than most other species. It is never sown by itself, but is always mixed with other grasses and forage plants, because it gives a full yield only in the second or third year." It soon dies out from poor and dry lands; and though adapted for moist situations, and consequently for irrigated lands, it will not endure stagnant water.

This grass must not be confused with the "large foxtail" and "small foxtail," species of Hordeum, which are such troublesome and injurious grasses. They are not even nearly related plants and bear no resemblance to each other.

Orchard grass (*Dactylis glomerata*) yields a heavy crop of excellent hay and is a good pasture grass for woodland pastures, yielding excellent early grazing. "The aftermath is unequaled in amount by any of the grasses ordinarily cultivated for hay." Professor Scribner says orchard grass has been known to yield 27,905 pounds of green forage, 11,859 pounds of hay, and 11,910 pounds of green aftermath per acre.

The success of orchard grass for woodland pastures has already been demonstrated in the region of Scotia and Arcata. It has also been tried with success between Willits and Sherwood. The main objection raised against it is that it is difficult to obtain a good stand during the first year. This difficulty can largely be obviated by sowing the seed of some rapidly developing grass, such as tall oat grass or Italian ray grass, at the same time. These will also act as fillers or bottom grasses, occupying the spaces usually left between the tufts of orchard grass. Moreover, Professor Scribner states: "The tendency of orchard grass to form tussocks is much diminished and the sward greatly improved where sown with other grasses." He also recommends heavy rolling "for checking or preventing the tufted growth which this grass naturally assumes; by this operation the tufts are pressed down to the level of the other grasses and the turf becomes more uniform." When sown alone, 3 to 4 bushels of seed are required to the acre.

Ray grass (*Lolium* spp.). Three distinct varieties are sold by seedsmen, and much doubt and confusion exist as to their relative

merits and uses and as to the differences by which they may be distinguished.

Italian ray grass (*Lolium italicum* A. Br.) (fig. 4) is a rapid-growing grass, forming a dense turf, and in Europe is valued as one of the best hay grasses for temporary pastures and as a nurse crop for red clover, orchard grass, or meadow foxtail. As it runs out in two or three years, it is not recommended as the sole ingredient of permanent pastures. Professor Scribner states that "on stiff, heavy clays, or on very dry soils, it does not do well, but on good, calcareous loam or marls, or on moist, loamy sands, when the soil is in good condition, it is very productive, and no other grass repays manuring so well. Few grasses develop more rapidly than this, and where the soil is rich and its fertility maintained by applications of liquid manure, cuttings may be obtained within three or four weeks from seeding, and at intervals of a month or six weeks successive crops may be harvested."

FIG. 4.—Italian ray grass.

On the Eel River bottom lands this is considered the best variety for cultivation, as it is such a rapid grower, shooting up even at the end of July or in August. The objectionable feature is its habit of running out after two or three years. This difficulty can be remedied only by resowing.

Italian ray grass may always be distinguished from other varieties by its few-flowered spikelets and long awns (beards) (fig. 4). The young foliage is of a bright green color.

English perennial ray grass (*Lolium perenne*) is much more permanent in character than Italian ray grass, but is less rapid in growth and starts later in the season. In England it is considered a very valuable forage plant, being particularly well adapted to the climatic conditions, but Professor Scribner considers that in this country it will never be as highly esteemed as timothy. Perennial ray grass is best suited to moist, rich loams or clays, and responds promptly to

the application of quick manures. Like Italian ray grass, the perennial species has but few flowers to the spikelet, but it is usually at once distinguished by the absence of awns. The young foliage is of a dark green color.

Australian ray grass (*Lolium perenne tenue*) is nothing more than a perennial ray grass which appears to have developed greater drought-resisting qualities by long cultivation in Australia. It is a somewhat wiry, tough form, especially adapted to cultivation on dry hillsides.

Many-flowered ray grass (*Lolium multiflorum*) is a variety having very large spikes and many-flowered spikelets. It has become abundantly naturalized in northern and middle California, and seems well adapted to the climate. It has recently become naturalized on the hills near Cloverdale, and is there considered a valuable forage grass. On the bottom lands of the Garcia and Eel rivers it grows luxuriantly, and in the former locality is used as a hay crop, yielding fully 3 tons to the acre. (Sheppard.)

Red clover (*Trifolium pratense*) is one of the heaviest producers of foliage, and the most nutritious of any of our cultivated forage plants. The climate over a large proportion of the State of California is not adapted to its culture, but there is no apparent reason why it should not thrive admirably in the higher mountain valleys of northwestern California. It is possible that the soil of Sherwood Valley may prove too sandy for this species, but its importance as a forage crop makes it well worth a thorough trial there. In heavy alluvial soil at the experiment station at Berkeley and on the Eel River bottom lands it has produced immense crops. It is frequently found, however, that red clover runs out after a few years. Professor Hilgard considers this is undoubtedly due to excessive acidity of the soil, which can be counteracted by treatment with lime (see p. 55). In England it is customary to sow Italian ray grass and red clover together, the former acting as a nurse crop for the latter, keeping out weeds and increasing the first year's yield, then dying out.

Red fescue (*Festuca rubra*) is a good bottom grass, having running rootstocks, which form a compact and durable turf, and producing a large quantity of fine root leaves. Red fescue endures varied conditions of soil and exposure, and is recommended both for woodland pastures and open meadows and for either sandy or clay soils. It should be tried in the mountain valleys, both on sandy alluvial or gravelly soils, and should also be used for the renewal of the open range, as its habit of growth will tend to check the washing of the soil and it withstands trampling by stock.

Redtop (*Agrostis alba*) is considered in the East as one of the best grasses for permanent pastures and meadows, making a "very resistant and leafy turf, which well withstands the trampling of stock." It needs a moist soil, and may prove useful in the higher valleys.

Reed fescue (*Festuca arundinacea*) is a tall, vigorous, and hardy

grass, yielding a large amount of hay, which is said to be of excellent quality. It has made a splendid showing at the experiment station at Berkeley, where it is now being propagated for distribution. The climate and soil seem to suit it well. It thrives best on comparatively moist soils and is well worth trial in mountain valleys and bottom lands as a mixture with other grasses.

Sheep fescue (*Festuca ovina*) is a valuable bunch grass for pastures on dry, sandy soils, especially if used in mixtures. Seed of the native varieties growing on the open ranges could be collected with little expense and used in the preparation of permanent pastures.

Awnless brome grass (*Bromus inermis*), though a native of Europe, was introduced into California from New Zealand about the year 1880 by the Agricultural Experiment Station of the University of California. It is a perennial with stout, creeping rootstocks and stems 2 to 5 feet high, and is useful both for pasture and meadow. It is a good winter grower. Its nutritive value is comparatively low, but it is well worth trial on the poorer sandy soils along the coast, as it is one of the most promising grasses for such situations. It is unusually resistant of drought, and when once established is somewhat difficult to eradicate. If sown alone, about 3 bushels per acre is recommended.

Tall oat grass (*Arrhenatherum elatius*), a perennial, has been found well adapted to the climatic and soil conditions at Berkeley. It makes an earlier start than almost any other winter grass grown, and produces a heavy stand of hay. Professor Scribner reports that on rich, clayey loam it has been known to yield 17,015 pounds of green fodder, 6,380 pounds of hay, and 13,612 pounds of green aftermath per acre. It grows rapidly, blossoms early, and when cut dries out readily. On good soils three or four cuttings may be obtained during the season. The early winter growth is much relished by stock, but it is said that later in the season it becomes somewhat bitter and cattle do not care for it except in the form of hay. It is therefore best adapted for permanent winter pastures which are to be laid off as summer meadows. Tall oat grass is not suited to heavy, moist soils, but thrives best on loamy sands or loams. It is said to grow on soils too poor to produce other crops, and therefore seems particularly well adapted to cultivation on the sandy bluff soils of the coast and the white-ash prairies as a substitute for mesquite (*Holcus lanatus*), to which it is far superior, both in quality and yield. It should also be tried, along with other grasses, in the mountain valleys at the headwaters of the Eel and Russian rivers. It is doubtful whether it would do well or prove as serviceable as other crops on the bottom lands of the Eel River and of Humboldt Bay.

As it does not form a very compact turf, tall oat grass should be sown in company with other grasses, particularly those which form a good leafy bottom and have running rootstocks, such as white bent. As it makes a good stand the first year, it might be sown with orchard

grass. The one species would largely remedy the defects of the other. In the East and in Europe tall oat grass is sown in the spring, but in the Southern States and in most parts of California September will be the best time for sowing. Professor Scribner recommends that if sown alone, 5 or 6 bushels of seed to the acre should be used, which at the present price of seed (about $3.25 per bushel, or $18 per 100 pounds) will be considered almost too heavy an outlay for the farmer. It seeds abundantly, however, and by purchasing a small quantity of seed one season enough can be harvested to sow a large area the following year. In this way, too, its merits and adaptability to local conditions can be better determined. "Owing to the structure of the seed, it may be sown deeper than most other grasses."

Timothy (*Phleum pratense*) is grown to a limited extent in Sherwood and Long valleys, but is said to "run out" within a few years. This is probably due to sowing alone and to pasturing too late in the rainy season, either of which methods of treatment renders the grass more liable to be trampled out. If used as a soiling or silage crop, this difficulty would probably not be met with. In the East and in Europe it is customary to sow timothy in mixtures with other grasses and clovers. It is considered satisfactory only on somewhat moist, loamy, or clayey soils and is apt to give a light yield on dry soils. It is not likely to succeed in northwestern California, therefore, except on bottom lands and in mountain valleys. Professor Scribner recommends sowing half a bushel of seed to the acre if sown alone, or about 10 pounds if the red or alsike clovers are grown with it.

Vetch (*Vicia sativa*), an annual climbing plant, grown in Europe for several centuries as a forage plant, is considered one of the best soiling crops for cool, moist climates. Except in the New England States and Canada, it has not been considered satisfactory on this continent, on account of its extreme susceptibility to dry, hot weather. On the coast of northern California, however, there seems to be no reason why it should not be grown for silage or for green fodder for milch cows, as it makes a luxuriant growth at Berkeley and at Scotia, keeping green till the middle of May in the former locality and till the middle of June in the latter. This plant makes good summer feed for horses, but should not be fed until in full bloom, on account of its diuretic action (Smith). It is said to materially increase the flow of milk in cows. Two bushels of seed are required to the acre.

White clover (*Trifolium repens*) is a perennial, forming an excellent turf. "The foliage, though produced in small quantity, is sweet, nutritious, and eagerly sought for by all kinds of stock" (Smith). In some places white clover is reported as being disliked by stock, but this is probably due to alsike clover having been mistaken for it, as the two are much alike in general appearance. Alsike clover is somewhat bitter and is not so well liked by stock. White clover is said to possess higher nutritive value than any other species. Some of the newer selected strains, such as giant perennial white clover,

have proved far superior to the ordinary wild form, yielding a much heavier crop of foliage suitable for hay. White clover grows well on the bottom lands of northwestern California around Scotia, Ferndale, Crescent City, etc., and thrives on a great variety of soils and under varied conditions. It should prove a useful forage plant on valley soils and is worth trial even on the open range. It is usually sown with other forage plants, such as Italian ray grass. If sown alone, from 6 to 8 pounds of seed to the acre is recommended.

POISONOUS PLANTS.

Mr. Sheppard, of Point Arena, reports that when he first settled there some forty-five years ago many young animals died, supposedly from eating "poison hemlock" (?), but that there are no longer any poisonous plants on his ranch, which is situated on the bottom lands of the Garcia River.

On Bear River Ridge Mr. Farley, who has handled cattle there for thirteen years, reports the presence of two poisonous plants, which, however, cause but little trouble. One he calls "larkspur;" the other is described as a plant "growing up like tobacco, about 2 feet high, and having a blue flower like larkspur." Calves are sometimes poisoned with the latter in the spring, while the grass is only a few inches high and stock are too "greedy" to carefully select their food. When the grass is 6 or 8 inches high cases of poisoning do not occur. The operation of "bleeding" is generally resorted to in cases of poisoning by these plants.

Bloating is reported as somewhat common on the ranges in spring, and bear clover (*Trifolium furcatum virescens*) is sometimes called "bloat clover," as it is considered the most common cause of the trouble. Usually bloating readily yields to the knife if the case is treated immediately.

Comparatively few specimens of poisonous plants were noted in the region, and we heard scarcely any complaint about cattle poisoning. The following species were observed:

Poison hemlock (*Conium maculatum*). A large patch was found among brush by the roadside, about 3 miles north of Miller.

Larkspur; cow poison (*Delphinium trolliifolium*) is reported "common on ridges throughout Humboldt County, where the stockmen call it cow poison" (Rattan). Apparently not common in the region, as we found it at only one place, viz, on a bank by the roadside at Acorn Station, near Korbel. It is also reported as occurring sparingly on Bear River Ridge, but a search failed to bring it to light. "Its toxic character has been questioned. Perhaps it is not equally poisonous throughout all stages of its growth" (Chesnut).[a]

Foxglove (*Digitalis purpurea*) appears as escaped from a cottage garden in the hills back of Point Arena; abundantly naturalized on

[a] Chesnut, V. K.; Preliminary Catalogue of Plants Poisonous to Stock; reprint from Annual Report U. S. Dept. of Agric., Bureau Animal Industry, 1898.

the Eel River bottom lands and elsewhere along the coast. In Europe horses are occasionally poisoned by nipping the plants from gardens or by eating hay contaminated with it.

Darnel (*Lolium temulentum*) is met with at Ukiah, Fort Bragg, Ferndale, and in Hupa Valley, but nowhere in great abundance.

False hellebore (*Veratrum californicum*) is common in moist places in Sherwood Valley and northward. Reported as poisonous to stock and said to be increasing in quantity. "The root and young shoots have been reported as being fatal to horses" (Chesnut).

Western Labrador tea (*Ledum glandulosum*) is reported by Miss Parsons[a] to be much dreaded by sheepmen, who claim that it poisons their flocks. Fortunately for stockmen, this plant is practically restricted in this region of the State to the white-ash prairies and sphagnum swamps, and is rarely met with in open pastures. The only places noted by the writer where stock would be likely to find access to it were some swamps on the cattle ranges of the Point Arena bluffs. It also occurs in similar spots on Point Reyes.

Buckeye (*Aesculus californica*). The fruit is generally regarded as poisonous to stock, but may easily be converted into food by washing and boiling. It is asserted that a small quantity will cause cows to slip their young (Chesnut).

Rhododendron (*Rhododendron californicum*) is reported from Oregon as poisonous to sheep (Chesnut); abundant on the White Plains.

Azalea (*Rhododendron occidentale*) is very much dreaded by sheepmen who drive their flocks into the southern Sierras for pasture. Investigation has shown that the leaves contain a poisonous substance (Chesnut); common along streams throughout northwestern California.

Calico-bush (*Kalmia glauca microphylla*), common on Trinity Summit, may possibly prove poisonous to sheep, as some of the eastern species of the genus are considered among the most dangerous of cattle poisons.

Milkweed (*Asclepias eriocarpa*). Several authentic accounts of the poisoning of sheep have been secured against this plant in Mendocino County. It is especially feared on very warm days by sheepmen when they are compelled to drive their flocks through dry, barren valleys. It sometimes grows on cultivated land, and is cut with hay (Chesnut).

Cocklebur (*Xanthium canadense*) appears in this region, as already noted. The young seedlings are reported from Texas as being rapidly fatal to hogs (Chesnut).

FUNGOUS PARASITES.[b]

The injury to the forage plants of the region under consideration, caused by parasitic fungi, is exceedingly slight, in so far as can be estimated from a rapid survey during a single season. The elevated

[a] Parsons, M. E., "Wild flowers of California, their names, haunts and habits." San Francisco, 1897.

[b] The notes here presented were prepared by Dr. W. C. Blasdale.

upland ranges are singularly free from pests of this sort, but in the moister bottom lands many of the common grass-inhabiting species of rusts and smuts are found.

Ustilago avenæ (Pers.) Jensen, oat smut, is seldom absent from fields of cultivated oats, and in certain seasons is said to cause considerable injury. It is occasionally found on the wild oats.

Ustilago holwayi, Dietel., is frequently found on *Hordeum nodosum*, but can scarcely be considered a pest.

Ustilago bromivora, Fisch., is found on *Bromus hordeaceus glabrescens*, but is not widely distributed.

Puccinia rubigo-vera (D. C.) Wint., orange leaf rust, is not uncommon on *Bromus secalinus* and *B. carinatus*, but the amount of injury effected by it is not great.

A yellow-spored Uredo is almost constantly associated with *Holcus lanatus*, and, were this grass a more valuable one, the rust might be considered a serious pest. Observations on this species in other portions of the State have shown that it persists throughout the year without the formation of other spore forms, which renders its identification impossible.

Uromyces minor, Schroet., clover rust, frequently injures certain species of Trifolium, especially *T. dubium* and *T. microdon.* In other portions of the State it is especially injurious to *T. gracilentum.*

What is probably the uredo stage of *Uromyces striatus*, Schroet., was also found in abundance in a single locality on *Medicago lupulina.*

Pseudopeziza trifolii, Fckl., is widely distributed and injures nearly all the species of Trifolium, but especially *T. cyathiferum* and *T. microdon.*

The species enumerated below are of frequent occurrence, though of no special economic significance: *Æcidium sommerfeltii* Johanson, on *Aquilegia truncata; Æcidium hydrophylli* Peck, on *Hydrophyllum capitatum; Æcidium pseudo-balsameum* D. and H., on *Abies grandis; Actinonema rosae* (*Lib.*) Fr., on *Rosa gymnocarpa; Doassansia alismatis* (Nees) Cornu, on *Alisma plantago; Puccinia circææ* Pers., on *Circæa pacifica; Puccinia densa* D. and H., on *Viola glabella; Puccinia bistortæ* (Strauss) Wint., on *Polygonum bistortoides; Puccinia asari* Link, on *Asarum caudatum; Puccinia gentianæ* (Strauss) Link, on *Gentiana menziesii; Puccinia malvacearum* Mont., on *Althæa rosea* and *Malva* sp.; *Puccinia menthæ* Pers., on *Micromeria douglasii* and *Monardella undulata; Puccinia mesnieriana* Thuem., on *Rhamnus crocea; Puccinia nodosa* Ell. & Hark., on *Brodiæa capitata; Puccinia melanconioides* Ell. & Hark., on *Dodecatheon cruciatum; Puccinia mirabilissima* Peck, on *Berberis nervosa; Puccinia hieracii* (Schum.) Mart., on *Carduus lanceolatus; Puccinia plumbaria* Peck, on *Phlox gracilis; Puccinia symphoricarpi* Hark., on *Symphoricarpus mollis; Puccinia pimpinellæ* (Strauss)

Link, on *Osmorrhiza brevistylis; Puccinia wyethiæ* Peck., on *Wyethia angustifolia; Phragmidium subcorticium* (Schrank.) Wint., on *Rosa gymnocarpa; Phragmidium rubi-idæi* (DC.) Karst., on *Rubus parviflorus; Sphærotheca humuli* (DC.) Burrill, on *Collomia heterophylla; Synchytrium pluriannulatum* Farlow, on *Sanicula menziesii; Triphragmium echinatum* Lev., on *Selinum pacificum; Uromyces aterrimus* D. & H., on *Allium unifolium; Uromyces hyperici* (Schw.) Curt., on *Hypericum anagalloides; Uredo arbuti* D. & H., on *Rhododendron californicum.*

PHYTOGRAPHIC NOTES.

The southern portion of the region under investigation is included by Dr. C. Hart Merriam in his Transition Zone. The Canadian Zone covers a large part of Del Norte and northern Humboldt counties and the Hudsonian Zone occupies the highest mountain summits. Our general collections have not yet been completely worked up, so that we can not give adequate lists of the plants by which each of these zones is characterized.

In general features the flora over the largest portion of this region differs little from that of the region immediately north of San Francisco Bay. Some species of the latter area do not extend as far north as the region under investigation, but in their stead occur species characteristic of a more northerly climate. *Sequoia sempervirens* is the most characteristic tree, here reaching its greatest development and occurring throughout the area. Immediately along the coast occur other coniferous trees. In Mendocino County *Pinus muricata* and *P. contorta* are the prevalent species, and a few specimens of *Abies grandis* occur. The pines were not observed along the coast of Humboldt and Del Norte counties being replaced by *Abies grandis*, *Picea sitchensis*, and *Tsuga mertensiana.*

The highest summits of the South Fork Mountains, which separate Humboldt County from Trinity County, are characterized by a highly interesting flora, showing a close connection with that of the Northern Sierra Nevada, with which it is topographically connected by the Salmon and Scott ranges and Mount Shasta. Our collections from this portion of the region have not yet been completely worked over, but they contain such interesting Sierran species as *Arctostaphylos nevadensis, Caltha biflora, Dicentra uniflora, Kalmia glauca microphylla, Quercus chrysolepis vaccinifolia, Pentstemon newberryi, Ribes cereum, Sarcodes sanguinea, Spraguea umbellata, Vaccinium arbuscula*, and *Viola blanda.*

But little systematic work has been done on the flora of this region. Collections have been made by H. N. Bolander, C. G. Pringle, Volney Rattan, C. C. Marshall, V. K. Chesnut, Elmer R. Drew, W. C. Blasdale, M. A. Howe, J. P. Tracy, H. P. Chandler, Miss Alice Eastwood, and the writer. Bolander's and some of Rattan's notes are recorded

in the Botany of the State Geological Survey, and several of Marshall's novelties have been described in the writings of Prof. E. L. Greene. The only publications dealing directly with the flora of the region are those of Blasdale and Drew.

SUMMARY.

1. The principal industries of the region under consideration are stock raising, dairying, lumbering, and barking.

2. Lumber and tanbark are practically confined to the redwood belt, a narrow strip of country running nearly parallel with the coast line.

3. Dairying is practically restricted to a few points along the coast, at Point Arena, and particularly the fertile flood plains near Eureka and Crescent City. The mountain valleys at the headwaters of the various branches of Eel River seem to be well adapted to dairying where they are within accessible distance of a market or shipping point.

4. The best grazing areas are (a) the coast bluffs, particularly near Point Arena and in the Cape Mendocino country; (b) the mountain valleys above referred to, and (c) the upland ridges of the plateau. The plateau ridges furnish by far the largest grazing area. This plateau country is not adapted to general agriculture.

5. Annual (seed growing) grasses seem to be better adapted to the upland ranges than perennial ("root growing") species. They reproduce themselves from seed much more readily after trampling out than the perennial species and furnish a large amount of early winter feed.

6. Naturalized forage plants, introduced accidentally from foreign countries, such as alfilerilla, bur clover, rat-tail fescue, barley grass, and soft chess are proving better able to stand trampling and grazing than the native species.

7. The maximum carrying capacity of the ranges has been reduced from 5 acres per head of cattle to 10, 12, and, it is said, even 20 acres, within comparatively few years, through excessively high land valuations and consequent overstocking of the ranges. The result of our investigations shows, and it has since been confirmed by practical stockmen who have grazed some of these ranges for years, that not less than 8 acres of range (including the usual proportion of brush and timber) should be allowed to each head of cattle. At this ratio the range can be maintained, and even improved, with judicious handling. This ratio should be made the basis of valuation in the purchase of a range, the relative amount of open range and of woodland also being taken into account.

8. The principal secret of successful stock raising in this region is to allow abundance of grass to go to seed. Seeding grass knee-deep is not wasted, as is usually supposed, but insures an abundance of

feed for the following year, not only on account of the seed scattered, but because it provides a good seed bed.

9. Sheep are no more injurious to a range, when properly handled, than are cattle.

10. On account of the importance of the tan oak to Californian industries, an investigation of the resources of the State in this direction is desirable.

11. The protection of drinking holes preserves the water supply and adds greatly to the value of the range; wherever possible proper drinking troughs should be placed at a short distance from the spring and the spring itself should be fenced. Small springs are often ruined by trampling.

12. The maintenance of springs and streams by preserving the timber and brush in their immediate vicinity is of the greatest importance to the range; it not only conserves the water supply, but also affords shelter to the stock in cold, wet weather.

13. The importance of maintaining good fences around a range should not be overlooked, and wherever practicable it is found profitable to fence off a range into several pastures, giving each one a rest from time to time.

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[Common names are in roman; botanical names in *italics*.]

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BULLETINS OF THE BUREAU OF PLANT INDUSTRY.

The Bureau of Plant Industry, which was organized July 1, 1901, includes Vegetable Pathological and Physiological Investigations, Botanical Investigations and Experiments, Grass and Forage Plant Investigations, Pomological Investigations, and Gardens and Grounds, all of which were formerly separate divisions, and also Seed and Plant Introduction, The Arlington Experiment Farm, Tea Investigations and Experiments, and the Congressional Seed Distribution. Beginning with the date of the organization of the Bureau, the independent series of bulletins of the Division of Agrostology, the last number of which was 25, and of the other divisions, were discontinued, and all are now published as one series of the Bureau.

The bulletins published in this series are—

No. 1. The Relation of Lime and Magnesia to Plant Growth. 1901.
2. Spermatogenesis and Fecundation of Zamia. 1901.
3. Macaroni Wheats. 1901.
4. Range Improvement in Arizona. 1901.
5. Seeds and Plants Imported through the Section of Seed and Plant Introduction, etc., Inventory No. 9. 4351–5500. 1902.
6. A List of American Varieties of Peppers. 1902.
7. The Algerian Durum Wheats: A Classified List with Descriptions. 1902.
8. A collection of Economic and other Fungi Prepared for Distribution. 1902.
9. The North American Species of Spartina. 1902.
10. Records of Seed Distribution and Cooperative Experiments with Grasses and Forage Plants. 1902.
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